Instruments

THE MAGAZINE OF

Measurement and Control

Vol. 18
JUNE
1945
No. 6

INCLUDING Aviation Instruments

When the Power Plant — Afloat or Ashor — Wants the Facts . . . . It's TAGliabu

Power and TAG Mercurial Pressure Gages . . . Power and TAG Industrial Thermometers . . . For generations, the men who go down to the sea in ships and those who harness power ashore have looked to TAG for dependable, visual pressure and temperature data.

TAG Mercurial Vacuum Gages of the Open Cistern type with scale reading 0 to 31 inches, have the vacuum connection at the top of the mercury column so that, as the vacuum increases, the mercury rises. Those of the Absolute Pressure Type have the vacuum connection at the cistern—the readings indicating absolute pressure (vacuum) and not simply pressure reduction below atmospheric.

Write for catalog No. 1125C-1 *today*

These thermometers meet all Navy and Maritime Commission specifications. They are used for all applications such as steam lines, brine lines, refrigeration, etc., where a full size scale reading thermometer of the highest accuracy is required.

PORTABLE PRODUCTS CORPORATION

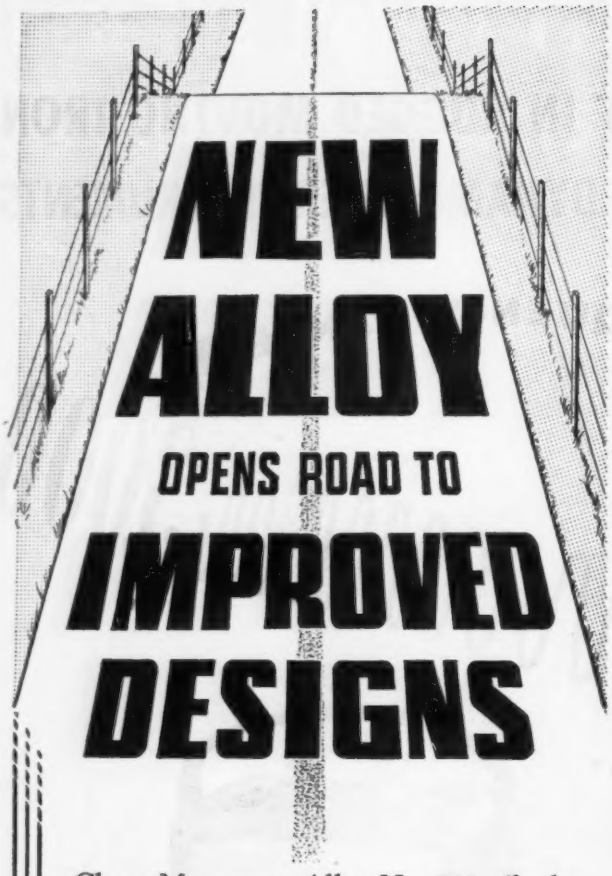
C.J. TAGLIABUE DIVISION . . . TAG *Instruments for Indicating Recording and Controlling*

PARK & NOSTRAND AVES., BROOKLYN 5, N.Y.

Now ACCURACY IN RUGGED MOVING IRON VANE AND DYNAMOMETER INSTRUMENTS

OVER THIS ENTIRE FREQUENCY RANGE

25 ~~~



NEW ALLOY OPENS ROAD TO IMPROVED DESIGNS

Chace Manganese Alloy No. 772 affords a unique combination of engineering properties that opens the way to many better-designed post-war products.

Briefly, those properties are: an electrical resistivity 60% higher than most commonly used alloys . . . a temperature coefficient of expansion higher than that of any other strong alloy . . . a thermal conductivity only 2% that of copper . . . such strength and ductility that it can readily be machined, stamped, drawn, flanged, or extruded.

Chace Alloy No. 772 is ideally suited for low temperature resistor applications . . . for the reduction of heat losses.

Chace Alloy No. 772 is being produced in sheets, strips and rods. Bulletin No. A-942—detailing physical properties and suggesting applications—is yours for the asking.

W. M. CHACE CO.

Manufacturers of

Thermostatic Bimetals and Special Alloys

1609 BEARD AVE • DETROIT 9, MICH.

Instruments

Vol. 18 JUNE 1945 No. 6

COVER: One of the control rooms at Neches Butane Products Co., Fort Neches, Texas. *(Courtesy The Foxboro Co.)*

EDITORIALS: Union jurisdiction; School exhibits 377
By M. F. Béhar

CALIBRATING POLYPHASE P-F. INDICATORS 379
"One-man" apparatus
By J. T. Cataldo

SAD STORY OF UNDER-INSTRUMENTED PLANT 382
and how proper remedies were applied by The Old Trouble-shooter

ELECTRIC MOTORS 384
for instruments and control apparatus
By Harry D'Almaine

ELECTRIC GAGING METHODS 389
Comprehensive data on a-c. bridge circuits
By H. C. Roberts

Aviation Instruments Department

AUTOMATICALLY-CONTROLLED DYNAMOMETERS 397
By Guy Bartlett

"WE LIVED—A VETERAN PILOT DIED" 398
By W. T. Bryan

ARMY AIR FORCES SHORTS:
Flying Weather by Psychrometer 398
Speeding Armature Repair 402
Reclaiming Cleaning Fluids 404

SHOP KINKS:
Chart reroll idea ..... By A. A. Jacobs 406
Calibrating tacs in planes ..... By M. J. Wiggins 406

Instruments in the War Effort

Servomechanisms 378
New Watch-winding Method 420
Captured Signal Equipment 420
Dye Aids Tropicalization of Instruments 420

New Instruments Department 422
Indicators, recorders, meters, controllers, inspection devices, etc., for plant, field, aircraft and laboratory

INSTRUMENT SOCIETY NEWS 444
MANUFACTURERS' NEW LITERATURE 448
ADVERTISERS' INDEX 450

Published Monthly on the 15th by

THE INSTRUMENTS PUBLISHING COMPANY

1117 Wolfendale Street, Pittsburgh 12, Pa.

RICHARD RIMBACH, Publisher — Major M. F. BEHAR, Editor

FIELD REPRESENTATIVES

MEMBER Audit Bureau of Circulations

James Condon, 36 Myrtle St., *Boston 14*, Mass. (Lafayette 0829). R. K. Farnham, Room 617, 17 East 42nd St., *New York 17*, N. Y. (Murray Hill 2-0821). Harold W. Haskett, Keith Bldg., *Cincinnati 2*, Ohio (Main 4260); Room 615, 360 N. Michigan Ave., *Chicago 1*, Ill. (Andover 4299). James R. Wright, 915 Olive St., *St. Louis 1*, Mo. (Chestnut 1965). M. D. Pugh, Room 212, 541 S. Spring St., *Los Angeles 13* (Tucker 7981). C. F. Goldcamp, 1117 Wolfendale St., *Pittsburgh 12* (Fairfax 0161); 859 Leader Bldg., *Cleveland 14* (Cherry 2261).

Annual Subscription: U. S. $2.00.

Copyright 1945 by The Instruments Publishing Company.

Entered as second-class matter January 26, 1932, at the post office at Pittsburgh under the Act of March 3, 1879.

Subscribers: Note that while the WPB Paper Limitation Order is in force—

1. Send notices of changes of address before you move. Copies will not be sent to replace those not received by reason of moving. Two months' advance notice should be given to assure change of stencil in time.

2. Renew your subscription before it expires. If you do not remember the expiration date, look for it on the address stencil. Renewal notices will continue to be sent before expirations, but *only one notice* will be sent to each subscriber and renewal must be received within fifteen days.

3. No single copies will be sold. Back copies can no longer be furnished.

4. No new or renewal foreign subscriptions can be accepted.

Instruments THE MAGAZINE OF Measurement and Control

M. F. BEHAR, Editor

Labor Unions' Jurisdiction—Replies from Both AFL and CIO

ON last month's editorial page appeared in full the letter we sent to Messrs. Green and Murray, transmitting copies of a letter we had received from an instrument department head, whose name was withheld but whose report of conditions was factual and detailed. Here are brief extracts as a reminder:

> It will take labor STATESMANSHIP to settle, for the good of all, the questions raised in the letter which follows. . . . Instrumentation is a physical science. A plant instrument department is "one famous physicist multiplied": its joint "know-how" surpasses that of one scientist; its joint work is professional; its members should be allowed to do ANY instrument work. Do you not agree with this view?—M. F. BEHAR, *Editor.*
>
> . . . I am particularly interested in craft boundary lines. . . . A grievance has been filed with the plant management by the machinist group. They want the lathe removed from the instrument shop. The outcome will probably be based on the answer to the question—"Is it general practice for an instrument shop to have and use an engine lathe?" . . . Other similar problems are already on the horizon in connection with piping, tubing and using an oxy-acetylene torch on work. . . .
>
> Is there any protection against the older and organized crafts for the Instrument Man? Is he going to get squeezed out by the other groups? . . .
>
> Yes, at times an instrument man does "border-line" jobs, but in the long run aren't instruments creating jobs for other crafts besides ours? . . . [NAME WITHHELD]

Here are the replies:

UNITED STEELWORKERS OF AMERICA
CIO
1500 Commonwealth Building
Pittsburgh 22, Pa.

May 21, 1945

Dear Mr. Behar:

Mr. Murray has asked me to reply to your letter of May 17 in connection with an anonymous letter enclosed with it.

The CIO organizations have had a very realistic policy towards extending every cooperation to employees engaged in laboratory, research and development work. I doubt that any CIO organization would be raising a question about a group of experimental workers operating a lathe. If any such specific instance exists in connection with CIO, we would be most happy to give it our prompt attention.

If the situation involves, as I suspect, an A. F. of L. organization, then I suggest that the party involved take it up directly with the international office of the union effected.

Sincerely,

HAROLD J. RUTTENBURG
Research Director

AMERICAN FEDERATION OF LABOR
Washington 1, D. C.

May 24, 1945

Dear Mr. Behar:

Because of my lack of knowledge and understanding of the technical character of work which is dealt with in the letter you sent me and in the letter which you enclosed, it is difficult for me to make reply thereto.

Skilled workers who are especially qualified to do machinists' work (welding) and electricians who are skilled and qualified in doing wiring, insist and demand that they be recognized as skilled workers and qualified to do machinists' and electricians' work.

I gained the impression from your letter that the work in question to which you referred comes under the jurisdiction of the Machinists and Electricians organizations.

Very truly yours,

WM. GREEN, *President,*
American Federation of Labor

With great pleasure *Instruments* notes the promptness of these replies and their cordial tone. A philosopher said that "punctilio is the essence of statesmanship" and it is good to see that both the AFL and the CIO are capable of statesmanship—specifically, that their top officials are broad-minded and far-seeing. Unfortunately, decisions affecting instrument department work are made by local officials, many of whom are reported to be narrow-minded and short-sighted in their attitude toward Instrument Men. Unfortunately, it seems that local officials have never been directed by higher headquarters to stop pestering Instrument Men. (No: it is NOT like the lawyer's question "Have you stopped beating your wife?")

What *Instruments* maintains is that Instrument Men should be free from petty "jurisdictional" restrictions on their work, not only where the plant's instrument department is part of the company's research division, but where it is under the company's production division. No company should be forced to label all its Instrument Men as "laboratory" or "research" or "development" or "experimental" employees if many (or most) of them are Soldiers of Production.—MFB

An "Instrumentation Exhibit" in Every Scientific and Engineering School

IN handing us the following letter, the President of The Instruments Publishing Company told us, "Here's an idea for an editorial." The letter was evidently not written for publication (the original bears the earmarks of hasty dictation) but precisely because of its unstudied style, it has such a ring of enthusiasm that we prefer to let it speak for itself, and we hope that Professor Cole will forgive us for printing it.

The idea is not new, but our recollection is that the other science and engineering professors who put forth this idea during the past ten years or so were too hesitant and apologetic. Professor Cole does not pull his punches!

Another comment we may make at this time is that the instruments, valves, etc., for the proposed Rotation Loan Exhibits need not all come directly from their manufacturers: it is not only possible but probable that numerous types and varieties could be obtained from Surplus War Property.

Still another comment we may make is to remind our readers that *Instruments* does not and could not give an

"advisory" service that would pass on the relative merits of different makes of products. Professor Cole refers to "ill-advised" purchases. It seems to us that we've heard this before: not only University purchasing agents, but the shrewdest purchasing agents of the greatest corporations make occasional mistakes. All human beings make mistakes! And even an advisory board with the wisdom of Solomon could not solve all the individual purchasing problems of all individual schools.—MFB.

OREGON STATE COLLEGE
School of Science
Corvallis, Oregon

May 1, 1945

Instruments Publishing Company

Gentlemen: Probably nowhere is there a better opportunity to acquaint the future engineers and research directors —and the future purchasing directors—with the virtues of equipment for measurement and control than in the colleges and universities of the United States; probably nowhere is there a better opportunity going to waste than this one. Poorly paid as professors may be, they STILL are charged with the most important of all jobs—the very education of the future leaders of America.

Because of limited funds, college staffs are forced to use equipment of five, ten, twenty and thirty years ago—yes, even in post-graduate studies and in the demonstration lectures. It is true, too, that when limited funds are made available for purchases present staffs are not sufficiently familiar with the equipment available to make the wisest choice. Very much more aid in the choice of equipment could be given by an organization such as yours—call it an *Instruments* Advisory Committee and equip it COMPLETELY with the latest information on control, measurement, and even on special instruments and equipment. Too often college staffs (and others!) are sent a folder in 1½c mail: "New Hi-Precision, etc., etc. Now Available at Reduced Prices," and the ill-advised recipient purchases blindly and *hopes.*

Much could be done to remedy this condition through increased subscription to *Instruments*, establishment and furtherance by YOU of an Instrument Advisory Committee as sketched above, and, further, the encouragement of a Rotational System of Equipment Loan by manufacturers who are anxious to put their products in the hands of men who will be directly concerned with their purchase one, two, three, five and twenty years hence.

Industry even now is crying for men well-trained in Instrumentation—and it has not been able to find a man with a sound theoretical background and several semesters of Instrumentation simply because the present system of Purchase and Decay of Equipment is one far too costly for colleges and universities to make an attempt at keeping pace. I believe a Rotation system—though it means a slight investment to a manufacturer—will return far more than the wildest Sales Manager has yet dreamed.

If America is one of the most highly advanced technological countries in the world, one would scarcely believe it after four years of college or a look into any "modern" research laboratory—with the possible exception of a few larger concerns, of course.

LELAND G. COLE
Department of Chemistry

Your Servant, Sir

[From the May 1945 *Industrial Bulletin* of Arthur D. Little, Inc.]

SERVOMECHANISMS had important pre-war applications, but it has taken the war to demonstrate their many spectacular capabilities. Whenever some measurable variable must be held constant, be it temperature, rate of flow, liquid level, speed or position; or whenever a simple operation not involving judgment must be performed as the result of a change in some variable, a servo generally can be designed for the job.

The engineer defines a servomechanism as a system which accomplishes the precise control of massive elements at a high power level from a remote control station at a low power level. Thus the fundamental characteristic of servos is that a relatively weak signal, whether it be a beam of light striking a photocell or a truck driver jamming his foot down on the brake pedal, is used to control a comparatively large force.

The thermostat which controls home oil burners is a familiar example of a servomechanism. The temperature-sensitive thermostat signals when the temperature falls below a predetermined level; the amplified signal controls the motor which starts the burner. Similarly in gyro-actuated control devices, such as automatic pilots for planes and automatic ship-steering devices, the gyro itself is a small object incapable of doing much work and still maintaining its accuracy. The gyro only indicates a deviation from a set direction, such as when a plane yaws off course, or angular velocity, as when a gun in a moving tank starts to roll or pitch. The resulting signal, suitably amplified, controls hydraulic, pneumatic or electrical motors that produce correcting forces.

All servos include a return circuit from the object or function being controlled so that a check is always available. Actually the amount of control depends on the difference between the original and follow-up signals. Thus, in power steering gears which aid in maneuvering heavy vehicles, the turning of the steering wheel tends to open the valve that controls the torque on the front wheels, but the follow-up is arranged so that it is always trying to close the valve.

Servomechanisms are used extensively in aircraft. Undisturbed by altitude, fatigue or battle problems, they respond to indications of such factors as pressure and temperature to regulate gas flow to supercharger turbines, open and shut intercooler flaps, and maintain engine speeds. Where control must remain with the pilot, remote-control devices, employing servo-motors, permit him by turning a knob to position shutters, adjust propeller blade angles, and so on.

Among the most elaborate and precise of remote controls are the systems by which gunners may control one or more turrets without the heavy muscular exertion that would be required if the gunner himself had to hold the guns against the plane's slip stream. In these powered turrets the gunner moves only a sight. While he keeps the target properly positioned in the sight and feeds in the plane's air speed, the control system automatically computes the line of fire with regard to range, windage and the relative speed of plane and target; any errors between the position as required by the computer and the actual position are registered, thereby releasing the power which applies the proper corrective force.

A land application of the servomechanism is the gyro-stabilizer used on tanks to maintain the turret gun at its correct elevation regardless of the tank's pitch and roll. Over terrain where experienced gunners could not score 1 percent of hits, the stabilizer has been reported as enabling scores of better than 70 percent. After the war such a system may be applied to railroad passenger cars and other vehicles to keep cars or seats at an even level despite a rough roadbed.

Other applications in the field of industrial controls include regulation of slack in steel mill presses and precise registration of printing machinery, particularly valuable in color printing, where the slightest error in register mars the final print. Profile milling using a servomechanism is expected to have widespread use. In one application, the contour-cutting of large propeller blades for ships is controlled by a small model of the blade over which is passed an index. Changes in angles or surface contour may be regulated by shaving down or building up the model.

Apparatus for "One-man Calibration" of Three-phase Power-factor Indicators

By J. T. CATALDO, Associate Electrical Engineer, Material Laboratory, U. S. Navy Yard, New York

THE testing-and-calibrating of three-phase power factor indicators from a three-phase supply requires the use of numerous instruments and three or more men and is affected by voltage and current fluctuations. There is described herein an apparatus, developed by the author, which permits a one-man calibration of three-phase power factor indicators from a single-phase supply. Moreover, the calibration so obtained is independent of fluctuations in the supply voltage. While the theory of the calibration, using d.c. or a.c. has been suggested by earlier work[1], simplicity of operation was stressed in the development of the apparatus to be described and a number of improvements were made.

THEORY

A conventional three-phase Power Factor Indicator is shown diagrammatically in Fig. 1. The field coil (current coil) is connected in series with phase 2. The potential

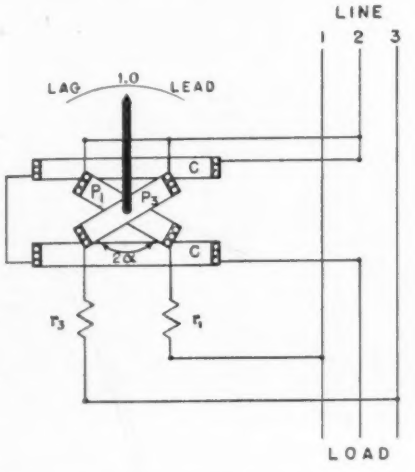


Fig. 1.

coils are connected across phase 1 and 2 and phase 2 and 3, respectively. It is common practice to make the angle between the planes of the potential coils (angle 2α) from 90 to 120 degrees. The scale length, as will be seen later, depends on this angle.

Fig. 2 is the current vector diagram of a three-phase power factor indicator at unity power factor. The current,

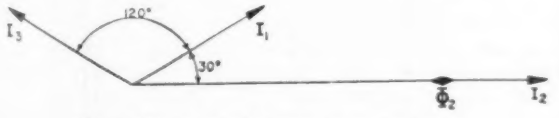


Fig. 2. Vector relation at unity power factor.

I_1, in the potential coil, P_1, leads the current, I_2, in the field coil by 30 degrees. Hence, I_3, the current in the potential coil, P_3, leads I_2 by 150 degrees. By passing a current, I_2, in the coil C, a field will be set up in the coil. This field and the currents in I_1 and I_3 will produce a torque on each of the coils. The coils P_1 and P_3 are mechanically and electrically connected so that the moving element will deflect until the resultant torque on the system is zero. The torque on P_1 will be:

$$T_1 = -K_1 \phi_2 \sin (\alpha + B) I_1 \cos (\theta + 30°) \quad . \quad (1)$$

where: K_1 = proportionality and design constant
B = angular deflection
θ = power factor angle
ϕ_2 = total flux due to I_2
I_1 = current in P_1

The torque on P_3 will be:

$$T_2 = K_3 \phi_2 \sin (\alpha - B) I_3 \cos (\theta - 30°) \quad . \quad . \quad (2)$$

The resultant torque at balance then will be:

$$K_1 \phi_2 \sin (\alpha + B) I_1 \cos (\theta + 30°) = K_3 \phi_2 \sin (\alpha - B) I_3 \cos (\theta - 30°) \quad . \quad . \quad . \quad (3)$$

If by construction $K_1 I_1 = K_3 I_3$ then:

$$\sin (\alpha + B) \cos (\theta + 30°) = \sin (\alpha - B) \cos (\theta - 30°)$$
$$2 \sin B \cos \alpha \cos 30° \cos \theta = 2 \cos B \sin \alpha \sin 30° \sin \theta$$
$$\tan B = \tan \alpha \tan 30° \tan \theta \quad . \quad . \quad . \quad . \quad (4)$$

If the coils are fixed so that $\alpha = 60°$

then:
$$\tan B = \tan \theta$$
$$B = \theta \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

The angular deflection B, from the initial position of the moving element at unity power factor, will be equal to the power factor angle of the load when $\alpha = 60°$. Referring to equations 1 and 2, for an indicator constructed with $\alpha = 60°$, for lagging power factor:

$$T_1 = K_1 \phi_2 \sin (60° + \theta) I_1 \cos (\theta + 30°) \quad . \quad (6)$$
$$T_3 = K_3 \phi_2 \sin (60° - \theta) I_3 \cos (\theta - 30°) \quad . \quad (7)$$

and for leading power factor:

$$T_1 = K_1 \phi_2 \sin (60° - \theta) I_1 \cos (30° - \theta) \quad . \quad (8)$$
$$T_3 = K_3 \phi_2 \sin (60° + \theta) I_3 \cos (30° + \theta) \quad . \quad (9)$$

At unity power factor, the fiducial position of the potential coils will be obtained with $B = 0$ and the moving element will deflect on either side of this position for power factors other than 1.0. When the power factor angle increases positively, the in-phase component of the current in one potential coil increases while the in-phase component in the other potential coil decreases. The coils, therefore, rotate so that the flux linkage of the first coil decreases while that of the second coil increases until the equilibrium position is reached. In the three-phase method of calibration I_1, I_2 and I_3 are maintained constant in magnitude and shifted in phase relationship. However, since only the in-phase component of I_1 and I_3 with respect to I_2 are effective and if currents of the correct magnitude and either in phase with I_2 or 180 degrees out of phase with I_2, as may be arranged by normal connections, are applied to the potential coils, any three-phase power factor may be simulated from a single phase supply.

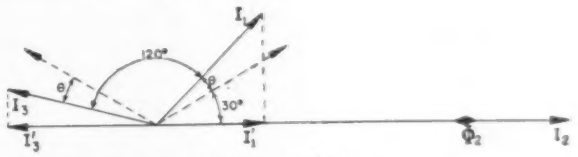


Fig. 3. Vector relation at lagging power factor.

From Fig. 3 (lagging power factor) the currents necessary to give the same effect as an equivalent power factor angle of θ are:

$$\left.\begin{aligned} I_1' &= I_1 \cos (\theta + 30°) \quad . \quad . \quad . \quad . \\ I_3' &= I_3 \cos (\theta - 30°) \quad . \quad . \quad . \quad . \end{aligned}\right\} \quad (10)$$

The opinions or assertions contained herein are the private ones of the author and are not to be construed as official or reflecting the views of the Navy Department or the Naval Service at Large.

(1) W. W. Hoke, "Calibration of Power Factor Indicators," *Electrical World*, Dec. 7, 1918.

Substituting potential values for current values,

$$I_1' = \frac{E_1}{R_1}\cos(\theta + 30) \qquad I_3' = \frac{E_3}{R_3}\cos(\theta - 30)$$

where R_1 and R_3 are the normal resistances of the potential circuits.

The ratio of these currents then is

$$\frac{I_1'}{I_3'} = \frac{R_3}{R_1} \times \frac{\cos(\theta + 30°)}{\cos(\theta - 30°)} \quad . \quad . \quad . \quad (11)$$

since it is assumed that $E_1 = E_3$ in magnitude.

When additional resistance is inserted in series with one of the potential coils, less current will flow through that coil, thus producing a proportional deflection. Assuming that both potential coils are connected across the same line and the resistance, R_x, is to be added in the P_1 potential circuit, an equation to evaluate R_x may be derived.

$$I_1'' = \frac{V}{R_1 + R_x} \qquad I_3'' = \frac{V}{R_3}$$

$$I_1''(R_1 + R_x) = I_3'' R_3 \quad . \quad . \quad . \quad . \quad (12)$$

$$R_3 = I_1'' \frac{(R_1 + R_x)}{I_3''} \quad . \quad . \quad . \quad . \quad . \quad (13)$$

Substituting equation 13 in equation 11, R_x may be evaluated for lagging power factors by the equation 15 below.

$$\frac{I_1'}{I_3'} = \frac{R_1 + R_x}{R_1} \times \frac{I_1''}{I_3''} \frac{\cos(\theta + 30°)}{\cos(\theta - 30°)} \quad . \quad . \quad (14)$$

$$R_x = R_1 \times \left[\frac{\cos(\theta - 30°)}{\cos(\theta + 30°)} - 1\right] \quad . \quad . \quad (15)$$

Similarly, if R_x is inserted in the P_3 potential circuit, R_x for a leading power factor (Fig. 4) may be evaluated from the equation below.

$$R_x = R_3 \times \left[\frac{\cos(\theta - 30°)}{\cos(\theta + 30°)} - 1\right] \quad . \quad . \quad (16)$$

The values of R_x calculated from equations 15 and 16 are valid for power factors from 0.5 lag to 0.5 lead for three-phase power factor indicators in which the resistances of the potential circuits are unequal. However, it can be seen from equations 15 and 16 that the R_x values are also valid for indicators in which $R_1 = R_3$.

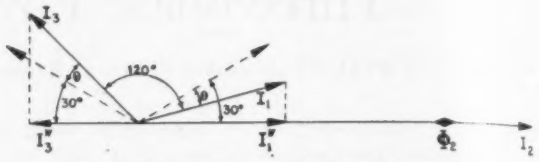


Fig. 4. Vector relation at leading power factor.

DESCRIPTION OF APPARATUS

The Power Factor Test Pier consists essentially of two variable autotransformers, a 3-pole double-throw knife switch, a single-pole single-throw knife switch, a switchboard voltmeter, a switchboard ammeter, two 20-ohm resistance loads, pilot lamp assemblies, a decade resistance box, toggle switches, and the necessary terminals and wiring.

TABLE I—Multiplying Factors for Computation of Resistance (R_x) to be Inserted in Series with Potential Coil.

Power Factor	*R_x in Series with P_1*	*R_x in Series with P_3*
0.50 lag	P_1 open	0
0.55	$14.23 \times R_1$	0
0.60	$6.66 \times R_1$	0
0.65	$4.16 \times R_1$	0
0.70	$2.87 \times R_1$	0
0.75	$2.07 \times R_1$	0
0.80	$1.53 \times R_1$	0
0.85	$1.11 \times R_1$	0
0.90	$0.78 \times R_1$	0
0.92	$0.65 \times R_1$	0
0.94	$0.53 \times R_1$	0
0.95	$0.47 \times R_1$	0
0.96	$0.41 \times R_1$	0
0.98 lag	$0.27 \times R_1$	0
1.00	0	0
0.98 lead	0	$0.27 \times R_3$
0.96	0	$0.41 \times R_3$
0.95	0	$0.47 \times R_3$
0.94	0	$0.53 \times R_3$
0.92	0	$0.65 \times R_3$
0.90	0	$0.78 \times R_3$
0.85	0	$1.11 \times R_3$
0.80	0	$1.53 \times R_3$
0.75	0	$2.07 \times R_3$
0.70	0	$2.87 \times R_3$
0.65	0	$4.16 \times R_3$
0.60	0	$6.66 \times R_3$
0.55	0	$14.23 \times R_3$
0.50 lead	0	P_3 open

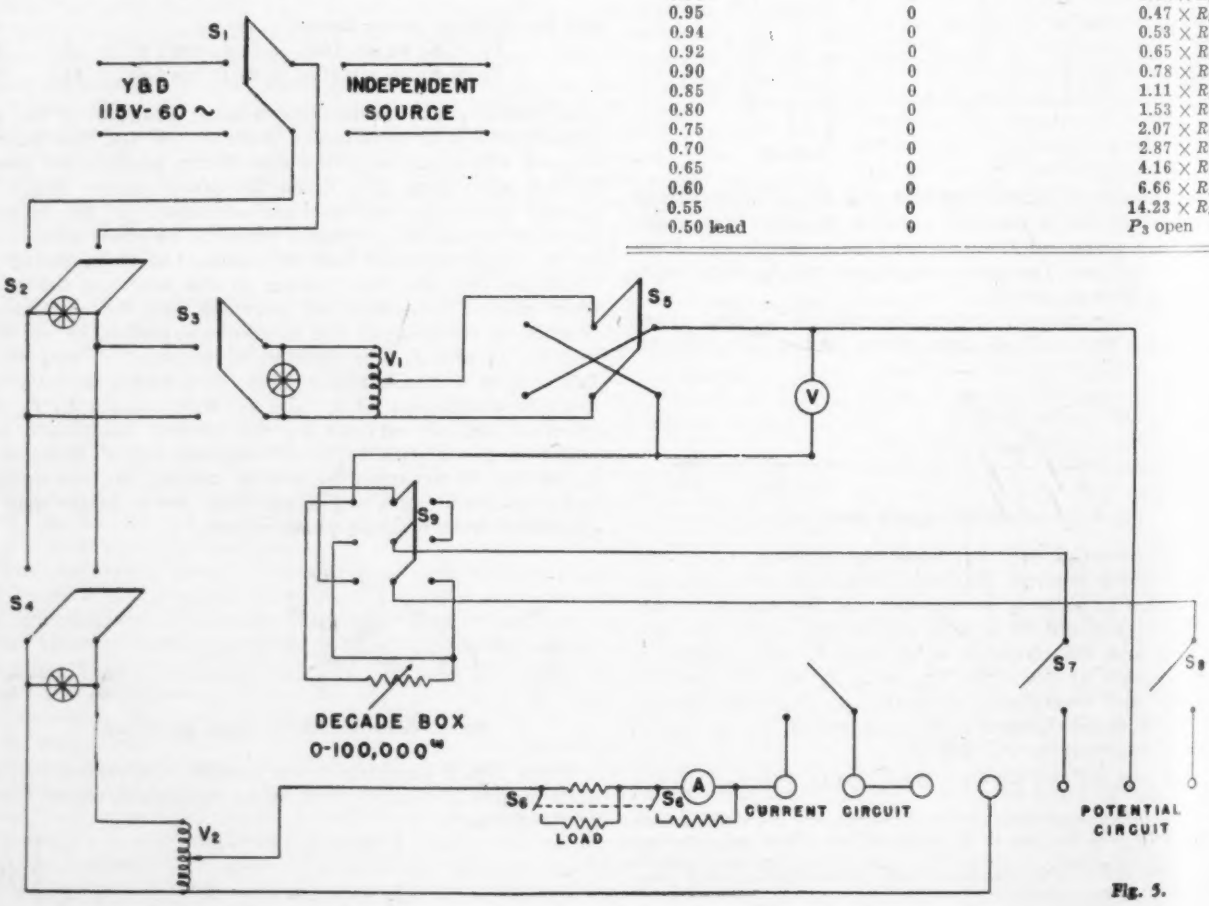


Fig. 5.

Fig. 5 shows the circuit diagram of the test pier. Employing this apparatus, one man can calibrate a power factor indicator for normal conditions of operation, such as 115 volts, 5 amperes, and 60 cycles. In addition, tests may be made to determine voltage influence, frequency influences, and current influence.

The instruments, switches, decade resistance box, and the terminals are mounted on a phenolic switchboard. A phenolic switchboard is used in lieu of metal because of the obvious convenience of mounting the switches and terminals. The switchboard instruments used were selected primarily because of their availability at the time the apparatus was constructed. For the purpose intended, any 1.0 percent switchboard instruments would have been adequate. The phenolic switchboard, fastened to a wooden enclosure,

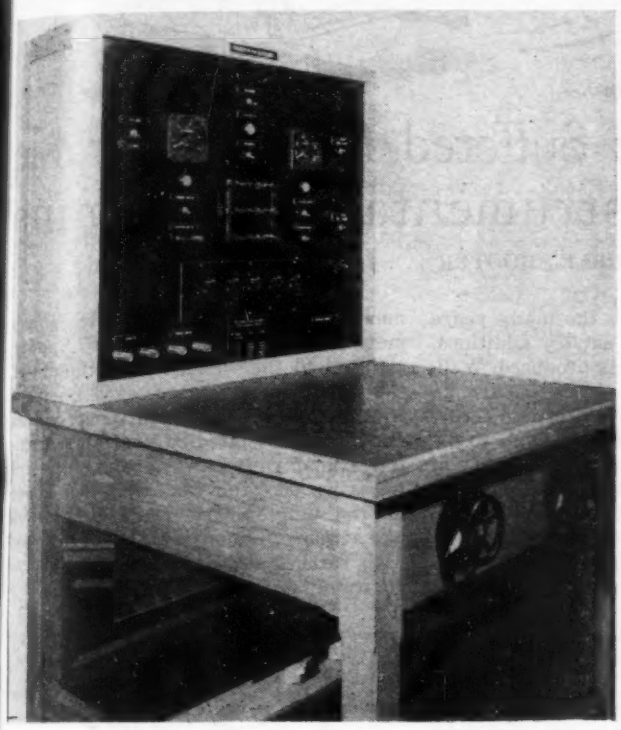


Fig. 6. General view of apparatus.

is mounted vertically on a sturdy hardwood table. The variable autotransformers are mounted on the front apron of the table (Fig. 6). The decade resistance box proper is mounted behind the switchboard with the control knobs projecting on the front surface of the switchboard.

OPERATION

The first requirement before calibration of the power factor indicator is to determine the normal resistance of the potential circuits. This resistance may be obtained by means of a portable Wheatstone bridge or an ohmmeter of good accuracy. Substituting these values in equations 15 and 16, R_x may be evaluated. However, for convenience of computation, Table I has been prepared. It can be shown that a 1.0 percent deviation from the actual value of R_x will not materially affect the instrument reading. Therefore, slide rule computations are sufficiently accurate for the evalution of R_x.

With the selector switch S_1 in the "Y & D" position, the apparatus is set for calibration on 60 cycles (Fig. 5). Switches S_2, S_3 and S_4 are thrown in the ON position; and autotransformers V_1 and V_2 are adjusted to the required voltage and current, respectively. Range switch S_6 is used to choose the range of the ammeter. When S_6 is in the "10-ampere range" position, it shunts the ammeter and, in addition, it connects the two 20-ohm resistors in parallel. The lead-lag switch, S_9, is used to insert the resistance (R_x) in either potential circuit. To obtain the proper direction of current in the potential circuits, reversing switch S_5

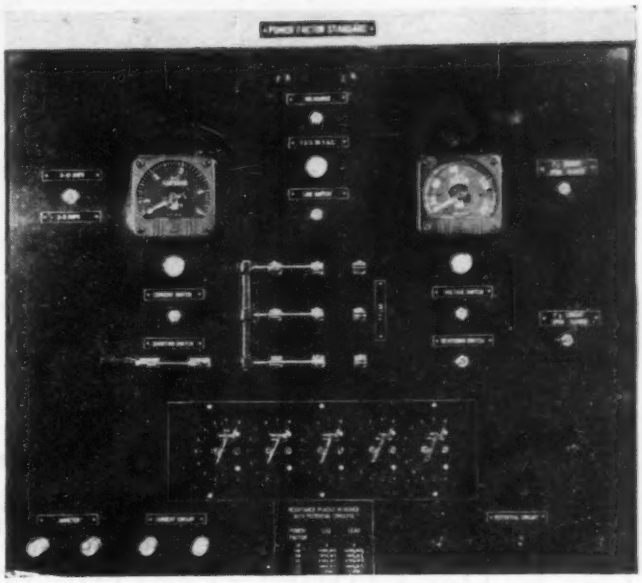


Fig. 7. Close-up of panel.

is provided. For calibrations at any other frequency than 60 cycles, S_1 is changed to the "Independent Source" position and the desired frequency is supplied to the apparatus by suitable motor generator sets.

CONCLUSIONS

The use of this apparatus materially reduces the personnel and time required to test and calibrate three-phase power factor indicators. The author has found that with this apparatus one man can test or calibrate these indicators in approximately one-tenth the time required to test or calibrate the same indicators by other methods and with a greater degree of accuracy.

ACKNOWLEDGEMENT: The author wishes to acknowledge the assistance rendered by Lieut. F. B. Morgan, USNR, and E. J. Jehle[2] in the preparation of this article; Mr. L. W. Murdock[3], supervisor of the Instrument Section of the Material Laboratory, for assistance in the adaptation of the apparatus for test work; and Jon Simon[4] for the preparation of the diagrams.

(2) Assoc. Electrical Engineer, Material Laboratory, U. S. Navy Yard, New York, New York.

(3) Materials Engineer, Material Laboratory, U. S. Navy Yard, New York, New York.

(4) Jr. Materials Engineer, Material Laboratory, U. S. Navy Yard, New York, New York.

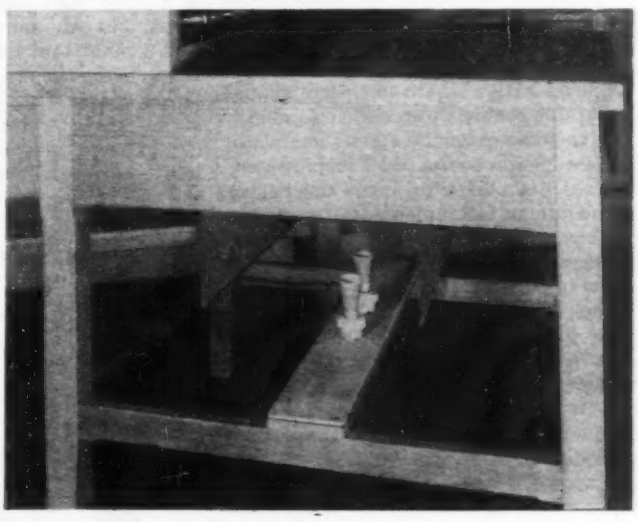


Fig. 8. View showing the load resistors.

The Case of the Plant that Suffered from Deplorable Lack of Power-factor Instrumentation Vitamins

By THE OLD TROUBLE-SHOOTER

WELL, The Old Trouble-shooter—unknown to *Instruments* readers as a writer but who has subscribed to *Instruments* through the years—has run into a new brand of currents, and so this is a story that will interest those connected with instruments and meters, especially such as have to do with alternating-current power. The new brand of currents are the

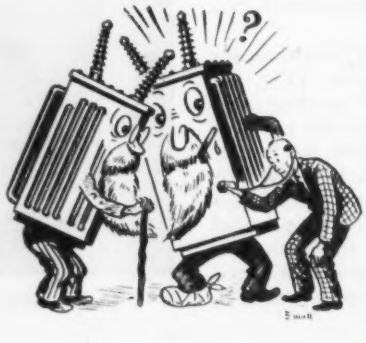
same old ones, still little understood, and in this case no one is hurt, except the bookkeeping department. Thus the story can be told.

The operation where this peculiar and deplorable condition prevailed (and still does to some extent!) must remain undisclosed, because the Old Trouble-shooter does not desire to harm the nerves of the human instruments that are ever-present, and cause additional troubles—manpower troubles on top of electric power troubles!

The peculiar and deplorable conditions came to light through contact with the extended operations of the organization when making a voltage investigation of the many operations involved, the company in question having a complex lot of equipments and (in addition to having a number of rather old generating units which operate into its main plant in a more-or-less haphazard fashion) having grown through the many years past, by various and sundry additions, to take care of products produced. Well, this company has had, so it appears, an excellent and prosperous life, financially. The voltage investigation was due to the more-or-less considerable number of coil failures in motors of various sizes, from time to time, without any apparent or at least observable reason.

Arriving on the job with a collection of instruments of the indicating and recording varieties, we commence to take readings, and from the very start we observe plenty of volts at every switch, fuse, contactor and what have you—even at the old generators and their connections. Actual voltages were very consistent, that is, high—as much as 110% to 115% of name-plate voltages of motors, generators etc., and even a large synchronous-motor-condenser was operating at a terminal voltage of so much above its name-plate voltage that it was almost unbelievable!

Oh yes, you want to know what kind of a plant. As I said, it mustn't be identified, but my impression was that it was a plant that had commenced operations many years ago with the *then* latest engineering (experienced understanding of the electrical game especially) but on closer study, the same obsolete constructions were still present in the mechanical and many other equipments, their installations, etc. I can mention that the blocks of power charged to the various departments of the manufacture were each metered with two single-phase watthour meters and their associated current and potential transformers. What was more interesting was the fact that every one of the single-phase watthour meters had at some previous time been equipped with ratchet stops to eliminate reverse rotation.



Although the man that seemed to be in charge of the electrical operations was of much experience, he could give no information as to why or when such ratchets were put on every one of the many meters. In fact he was not at all concerned with the voltages when shown that they were what they were, apparently having given no attention to the finer electrical problems of his extensive operations.

At the main generating station, we found an assortment of generators, transformers, and the usual plant items. Here also we found that the transformers were old and that for some unknown reason the outside feeder transmission voltages were much above 110% of name-plate voltages. We found also that the metering about the plant was

of the two-meter hook-up style; and that for as long as records were available the practice of charging power to the various groups of operations was a regular monthly procedure.

A little time checking through the records revealed that the charges made to the various groups or departments of manufacture could not be checked out near what seemed correct, so we commenced a systematic check of all watthour energy meters, and shortly, to make things easier and better, and in line with good operating practice, prevailed upon the management to make changes in transformer connections and hook-ups and reduce the voltage to near equipment name-plate design ratings. This was accomplished in one case with transformer connection changes on the main transformers; and in another case through the use of transformers to buck down the excessively high voltages.

After this was carried out, after the third day of the survey, the Old Trouble-shooter went to work nights and carried out what to him was an extremely interesting investigation — that of finding out what caused the large differences in meter registrations. On one feeder the differences were more than fifty divisions on one meter to one division on the other meter.

During the nights, at the lull periods of production and loadings, on graveyard shifts, we commenced our plan of re-educating ourself to the two-meter method of recording power use.

Taking one department—which had an isolated generator whose power was from waste heat installation—we found that the two meters on the feeder to this section of the plant operated about as follows:

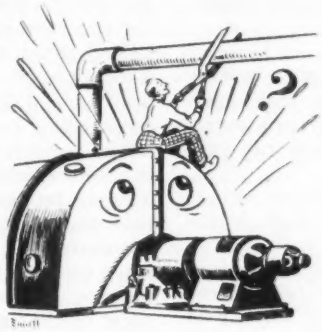
During the period when this generator was producing power in excess of that used on the metered side of the feeder, we observed the following:

(1) By highly exciting the generator field, the A phase meter would try to turn left, minus registration, while the C phase meter would turn right, showing that there was input to the feeder from the main power plant, when the opposite was true.

(2) By lowering the field current on the same generator, we observed that the A phase meter would turn right, showing power input to the feeder, while the C phase meter would try to turn left, again, the meters actually showed input to the feeder, when the opposite was true.

(3) Thus, when the generator on this feeder was either highly excited (high field current), or very low excitation (small amount of field current) even to point that lowered the voltage some, the feeder meters showed actual input to the feeder—the reverse being true as proved beyond doubt by the Polyphase Wattmeter which we connected in the circuit with the watthour meters.

After making the above observations, we wanted to know a little more about the two meters which were used to make power charges to the department, and so we had the engineer cut the steam



flow to the engine to the point that the generator almost acted as a synchronous motor, and proceeded again with the above check when the wattmeter actually showed input in kilowatts from the main power house to the feeder.

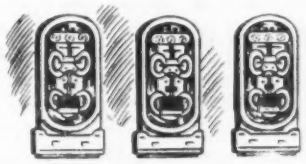
Under this condition we observed the following:

(1) When the generator was highly excited the same A phase meter turned left, and the C phase meter turned right, showing actual input to feeder.

(2) When the generator was excited with much less field current we observed that the A phase meter turned right and registered, and the C phase meter turned left.

(3) Again, as above, we showed actual input to the feeder, which was fact in this case, as shown by Polyphase Indicating Wattmeter connected in same metering circuit.

Next we went on a heavily-loaded feeder. The metering connections and equipments were the same; however, since the load on this feeder consisted of many induction motors, there was a



"Finally, polyphase wattmeters were installed"

large synchronous motor used also as condenser. We first observed this motor with much less field current indication on ammeter than its name-plate rating. Therefore we made no adjustments on field at the time; but, after installing the transformer to buck down the high voltage on this feeder, the then voltage was close to motor name-plate voltage; we then had to increase the field excitation current on this synchronous motor several points.

The following night, we made more tests and load checks. We found that by adjustment of the motor field current, we could (1) make each of the A and C phase meters run close to the same speed, (2) by highly exciting the motor field we could stop the A phase meter, and the C phase meter would rotate plus input to the feeder line, (3) we could lower the motor field current a great deal, stopping the C phase meter and the A phase meter would rotate plus input to the feeder line. In all cases the stop pawls on the meters would prevent reverse rotation. The polyphase indicating wattmeter showed input to *this* feeder, which was fact.

So this was a case of excessively high voltage, above 110% of equipment name-plate ratings, together with meters having ratchet stops, preventing substractive registrations of meters (power direction flow), resulting in incorrect power distribution charges being made to three departments. Credits should have been given, as power flow was actually from feeders into plant system most of the time (by reason of generating equipments on the feeders) producing more power than used on feeders.

Because of the high feeder voltages originally, generators and synchronous motor were operated with very low field currents. Note: The feeder having the synchronous motor also had a generator on end of line: generator was off line during time of field current adjusting on synchronous motor.

Fortunately, errors in departmental power charges which involved many hundreds of thousands of kilowatthours, according to meters, did not affect actual processing costs of the finished products: it was all in the family.

Finally, polyphase meters were installed throughout. After this, the actual charges for power to the feeders into which the generators were connected fell to near zero, and the accounting department is still wondering what it is all about.

On the same survey it was discovered that errors in meter multipliers had complicated the original recordings, else it seems someone would have long since picked up the conditions.

Once more, alternating currents are just the same as always. The associated equipments are all right, and the plant operations are improved through an interesting visit and checkup by

The Old Trouble-shooter.

EDITOR'S NOTE: This unusual story seems to refer to one manufacturing company, self-contained as to its own power generation and uses (not purchasing power from a utility) but keeping records of energy consumption by departments. At least one department is not only a "customer" of the company's central power plant but is at times a supplier of electric energy, having a waste heat utilization generator.

POSITIONING MECHANISMS, FOLLOW-UP MECHANISMS, SERVOMECHANISMS, ETC.

(Continued)

6. Deflection Beam Tube

Askania Regulator Co. have developed an interesting control tube for the operation of special servomotor systems. The primary signal is developed within a special cathode-ray tube whose electron beam is deflected by a signal impressed on the bias plates so as to fall on one side or the other of a circular target which is split along a diameter so as to form two output paths. A negative feedback, derived from the positioning of the load, restores the deflection of the cathode ray to a position where the output from each half of the split target is equal. This constitutes a null method, and offers many opportunities for extremely precise control.

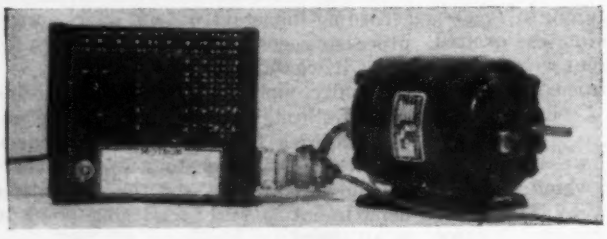
Positioning through restoration of the deflected beam to its balanced output position, or null point, can be accomplished magnetically, if desired, by use of a permanent magnet operating with translatory motion derived from a servomotor. The magnet is used to deflect the cathode ray in a desired manner.

This type of unit can be used to maintain constant voltage or current from a generator with an extremely high degree of precision.

The combination of displacing or restoring forces inherent in the manipulation of the input to the bias plates and the movement of the external magnet permit of a number of combinations so as to control the speed, temperature, motion or input power to any load, according to a predetermined cycle with a time base for the controlled function covering as short or as long a period of time as required. The system is especially adapted to d-c. negative feedback circuits with d-c. amplifiers.

7. Motron System of Remote Positioning Control

This is a system of electronic control of induction motors and servomechanisms which is quite new and, in consequence, war secrecy requirements do not permit of the disclosure of very much information. The system is manufactured by W. C. Robinette Co., South Pasadena, Calif. The manufacturer claims for this method the following points:



W. C. Robinette Company. Motron control unit hooked to a 1/50th horsepower induction motor.

A. Electronic speed control of induction motors, offering up to an infinite speed range.

B. Electronic interlocking to the smallest imaginable forces.

C. Automatic process control with the use of only small and simple attachments.

D. Servomechanism control of a high degree of sensitivity. (The mathematical results obtained by this method of servomechanism control could only be duplicated by conventional methods with an electronic amplifier with infinite gain and zero phase shift for all frequencies.) It is possible to demonstrate working models with a stable sensitivity of better than one part in 50,000.

E. Induction motor operation at speeds of 5 to 100 times line frequency synchronous speed. Since this motor operates essentially opposite to conventional induction motors, we call it the anti-induction motor.

The accompanying illustration illustrates a No. 2B Motron Control unit hooked to a 1/50-horsepower induction motor.

8. Electrotie System

The Electrotie system, manufactured and patented by the Electrolux Corp., is a modern improvement on the basic idea first proposed by Thompson and Lamme in 1894, who sought to tie in the d-c. motors on streetcars so as to have these motors operate in space phase synchronism with each other. In other words, they wanted these motors to start up in perfect unison, run that way and stop the same way. The trouble with the early development of this idea was that the units hunted badly and for many years this idea has lain dormant until the demands for precise control of speed and position of distant units, as, for instance, the aeilrons on aircraft, called for such a system.

The present Electrotie motor units are basically similar to shunt-wound d-c. motors, with the addition of a two-phase winding on the armature. The armatures are so connected that the two-phase alternating current produced ties the armatures of two distant motors together so that they will start up together, run together and stop together without hunting. This system of control will have numerous applications in the industrial field, as well as for military needs. The ability to start a series of motors driving a common load so that they will start up in perfect space phase relationship to each other is very important. Such a system will prevent spoilage of material that would otherwise occur during the period when other types of motor drives were being adjusted so that their driving speeds matched each other.

9. Speed Control

The simple control of motor speed automatically or manually, either at the motor location or from a distant point, without any tie-up with positioning mechanisms or servo systems, covers a very broad field of activity. Some of the newer methods in use which in some cases call for special characteristics in the motors are referred to here.

The electric governor, as previously referred to, has been used for many years for controlling the speed of motors, but the number of applications calling for this form of adjustable or fixed speed control has increased many times in recent years. This form of control seems best adapted to wound armature type motors for operation on either alternating or direct current. A typical application is the driving of a recorder chart for recording sound echoes for geophysical testing apparatus. It is being used for control of constant-frequency output from motor-generator sets. There are many other means of doing this, but where maintenance of an exact frequency is not required and the permissible deviation from the required frequency may be $\pm 1\%$, the use of the electric governor is a very simple means of achieving control. A means of obtaining speed control on induction motors with an electric governor employs a motor with a power-fed rotor and a relatively high-voltage low-current short-circuited winding distributed on the stator. The governor is connected into this stator circuit. The purpose of this arrangement is to make it unnecessary for the governor to have to handle as high an amperage at full load on a motor as an ordinary induction motor of equivalent rating would take from the line. In other words, by reversing the relative position of the primary and secondary circuits in the motor and putting the governor in a secondary circuit whose voltage can be raised and current flow reduced, it is possible to increase the reliability of the governor action and lengthen the governor life. Pitting of the governor contacts is primarily a question of the amount of current carried. There are also some possibilities for saturable-core reactor control of a-c. motors with practically sparkless operation of the governor, which handles only the grid bias voltage on thyratrons, which in turn control the d-c. current to the reactor.

ELECTRIC
for Instruments and

By HARRY D'ALMAINE

(Continued

MOTORS

Control Apparatus

Industrial Sales Research, New York

(Continued from May)

Very good speed control with practically sparkless operation of the governor contacts is secured with shunt-wound d-c. motors where the governor is reverse-acting and acts to short out a resistance in series with the field if the motor speed tries to rise, and as the motor speed drops and the contacts open the series resistance is inserted, thus weakening the field and causing the speed to increase again. In this application, since the contacts do not actually handle the full-load current of the motor as in a series motor application, they give a very good account of themselves.

The Lee Engineering & Mfg. Co. hold the basic patent on a very sensitive type of electric governor. This manufacturer has developed an induction motor control which permits of speed control from close to zero speed up to the full-load speed of the motor. In this application, the motor is of the same construction as described, with power from the line feeding the revolving rotor field structure and the governor control operating in the short-circuited stator secondary. In this case, the governor, instead of being mounted so as to be driven by the rotor of the motor whose speed is being controlled, is mounted on the revolving stator of a capacitor start and run synchronous control motor, the rotor of this motor being mounted on an extension of the controlled motor's shaft. Power to the revolving stator of the control motor is fed to it through brushes mounted on the stationary frame of the motor whose speed is being controlled.

If, for instance, the control motor consists of an 1800-r.p.m. synchronous motor frame equipped with a reverse-acting governor, the contacts of which operate in the secondary circuit of the motor whose speed is being controlled, it becomes apparent that if the governor is adjusted to 1800 r.p.m. it will be satisfied by a condition in which the revolving stator to which it is attached revolves at 1800 r.p.m. synchronous speed. In this condition, the governor contacts would be open, and the secondary circuit of the main motor being open, the motor does not have to revolve at all, but would stand still, since the relative speed between the synchronous motor rotor which is at standstill with the main motor and the stator of the synchronous motor is 1800 r.p.m. If the governor is now adjusted so as to equal a speed of 1700 r.p.m., since it is reverse-acting, the contacts would remain closed as long as the speed was above 1700 r.p.m. This would close the circuit to the secondary of the controlled motor, whose rotor would then revolve in an opposite direction to the rotation of the control motor's stator until a speed of 100 r.p.m. was reached.

The relative speed between the control motor's stator and rotor is now again 1800 r.p.m., which satisfies the synchronous control motor, though the revolving stator is going at actually only 1700 r.p.m., which corresponds to the setting on the governor. The governor setting being satisfied, the main or power-drive motor continues to revolve at 1100 r.p.m with full-torque output.

An induction motor could be substituted for the synchronous motor as the control motor unit, but would be more inclined to be subject to variations due to line voltage variation, friction in the brush contacts, operating temperature variations, or other factors which might tend to cause the normal speed of the motor to wander. The use of the synchronous motor, having a substantial pull out of synchronism torque, would maintain that speed regardless of substantial variations in line voltage or changes in brush friction, and thus could be relied on to give more positive speed control of the main drive motor.

Another possible means of adjustable speed control of motors to meet the requirements occuring in a large variety of industrial work, machine tool drives, process controls and other applications, is to use as the driving motor a d-c. unit which is fed through a thyratron rectifier unit. An example of this is the General Electric Co.'s Thy-mo-trol and the Weltronic variable-speed control manufactured by the Weltronic Co. Other manufacturers, including Westinghouse, make similar types of vacuum-tube motor controls.

The field of special types of controls and special motors all intended to give variable and adjustable speed control with a variety of output characteristics has been numerous, and it would be virtually impossible in this study to mention all of them. We have endeavored to mention some of the more interesting from the standpoint of their latter-day commercial exploitation, as well as some of the newer and potentially more important developments.

Summary of Analysis of Motors and Motive-power Units

The outstanding fact derived from this review of motive-power units used in, or related to, the field of instruments and automatic-control apparatus is the very considerable development of motors, not as distinct units, but as parts of power-controlled systems calling for much original thinking and a new and unfettered approach toward the whole field of electric motor development.

Conventional motor manufacturing, with few exceptions, has not produced these new developments. Rather, they are the outgrowth of the minds of men who were not only familiar with motors in the ordinary categories, but whose knowledge of electronics and basic physics permitted them to think of the problem of motive power application in an overall sense. The established motor manufacturing industry, therefore, as was stated previously, faces a challenge to keep abreast of this type of development, which will bring about many additional far-reaching improvements in industry.

APPLICATIONS OF ELECTRIC-MOTOR-OPERATED INSTRUMENTS AND CONTROL APPARATUS

In presenting the following series of typical applications, we have tried to group the available material so as to present it with some degree of logic. This presentation does not exactly parallel the order in which the motors were presented, ranging roughly from the synchronous chart-drive motors on up to polyphase valve control motors. Many pieces of apparatus in a given manufacturer's line use several sizes and kinds of motors, or are tied in with the control of other apparatus using larger motors.

In the field of instrument controllers, the development of air-operated units reached such a high degree of acceptance that probably 70 to 80% or more of all such instruments in use in chemical plants, oil plants, synthetic rubber plants and similar establishments, use compressed air rather than electric operation. The reason for this in the past has been largely because the air-operated equipment involved an absence of electrical contacts and this was a factor where instruments were located in hazardous atmospheres.

Another factor that contributed to the supremacy of air was flexibility of control, superior to what then was possible by electrical means. In the last five years or so, the development of electric-motor-operated controls has been so extensive as to provide, almost without exception an electrical means of accomplishing everything that was accomplished with air, plus the added advantage that, whereas air-operated instruments had to work over transmission distances running from 10 to 50 feet maximum, the growing trend toward centralized control outside the hazard area now makes electrical operation over distances of hundreds of feet distinctly advantageous.

Thus, there is a reversal of trend toward an increasing use of electrically-operated instruments. The development of electronic devices in bewildering number has played no small part in this trend toward electrical operation.

This again represents a favorable picture from the standpoint of the motor manufacturer catering to this field. Not only are markets for instruments in all lines expanding due

to normal economic growth, but technological developments are tremendously accelerating this.

1. Temperature and Combustion Control

The manufacturers referred to under this heading do not by any means confine their activities to this single field. The examples given are intended to be broadly illustrative. The sequence in which the manufacturers are mentioned is not intended in any way to be discriminatory.

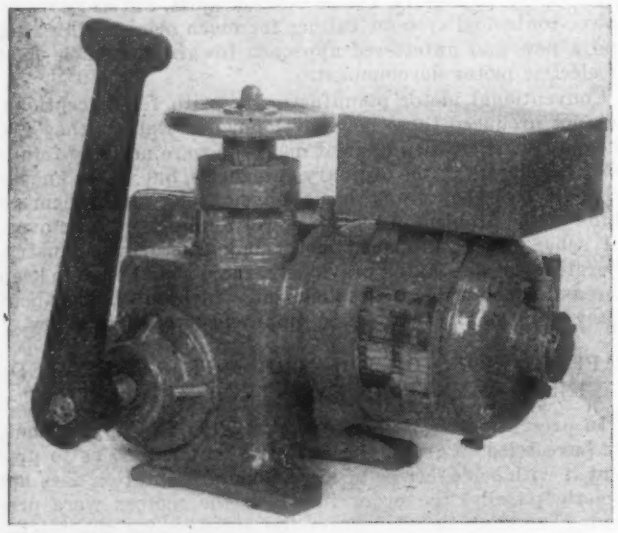
The basic system of combustion control manufactured by the Hays Corp. uses four motors:

1. Master Pressure Regulator. This uses a three-wire reversible shaded-pole geared motor, oil immersed. This unit, manufactured by the Barber Colman Company, is shown in an accompanying illustration. This motor is also used for operating valves.

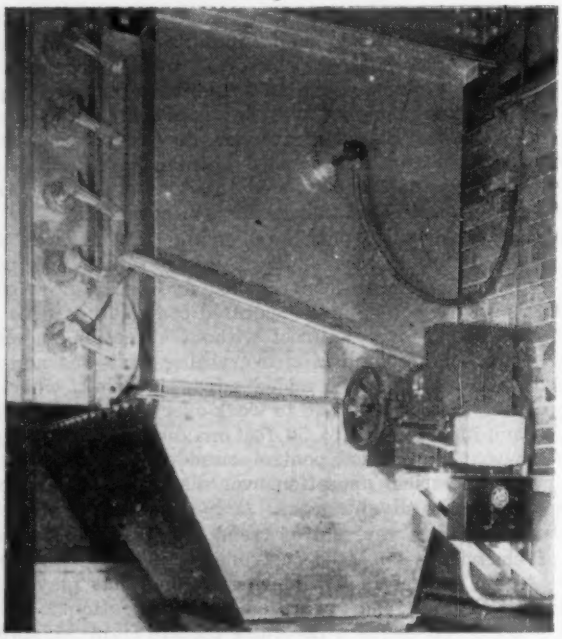
2. Air Flow Controller, operating air inlet dampers, uses a variety of capacitor start-and-run 1750-r.p.m. induction motors, dependent on the size of the dampers to be operated. These motors are equipped with double-worm gear reducers, and are ball-bearing fibre-glass insulated. Four different units are used, rated 1/20 h-p. delivering 50 ft-lbs. torque, 1/6-h-p. and 200 ft-lbs. torque, ⅓-h-p. 500 ft-lbs., and ¾-h-p. 1,000 ft-lbs.

3. Fuel Feed Controller, operating the stoker—uses the same type of motors as in Item No. 2 above.

4. Air Outlet Dampers—use same type motors as No. 2 above.



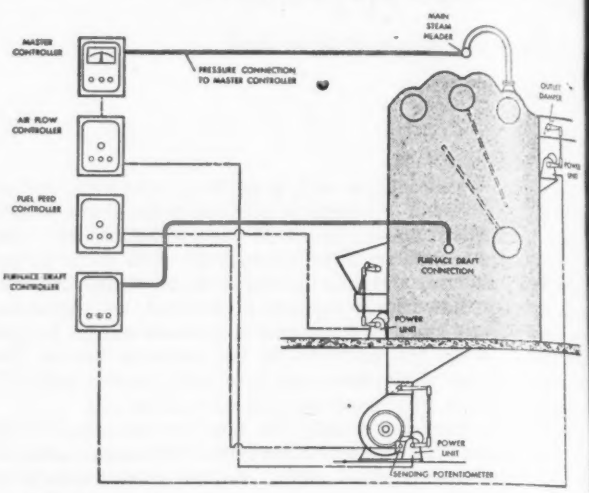
Hays Corporation EA-50 power unit. Motor is a Janette 1/25th horsepower, 960 r.p.m.



Hays Corporation EA-200 operating an outlet damper.

It is the belief of this manufacturer that process plants in the consumer products categories will undertake considerable expansion after the war. This would include such things as foods, clothing, and so forth.

A schematic diagram of the Hays automatic combustion control is shown on the accompanying outline print.



Hays Corporation. Boiler control system, showing applications of two power units.

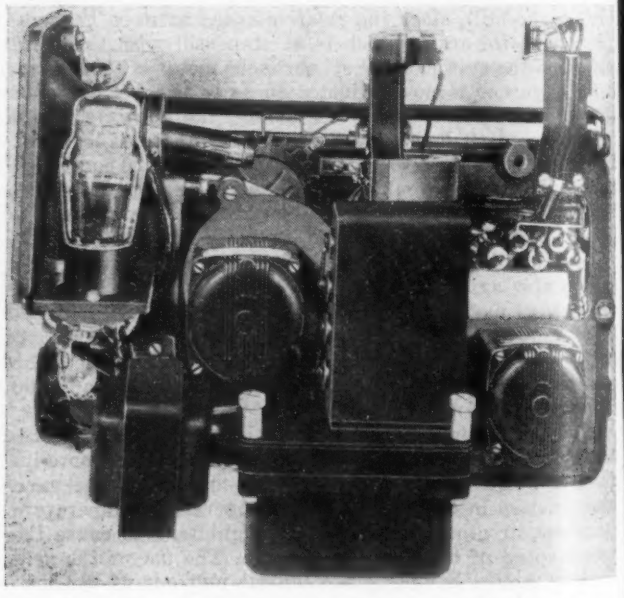
The C. J. Tagliabue Div., in their Celectray pyrometers, use Bodine Electric Co. Type K capacitor motors for two purposes. A synchronous motor feeds the chart, while a reversible induction motor operates the pen drive. These units can be seen in the accompanying illustration.

The Tag Celectray indicating controller uses a Bodine Type K capacitor induction motor with built-in speed reducer for operating the throttling control mechanism.

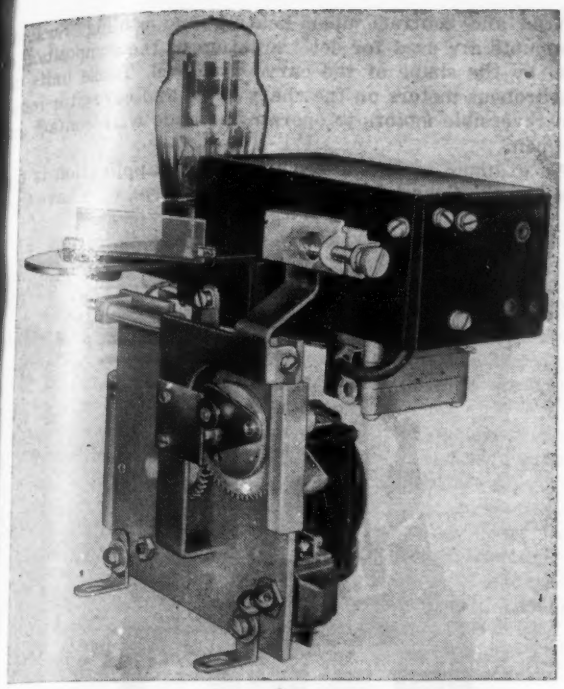
For the potentiometer recorders, controllers and many other industrial instruments manufactured by the Foxboro Instrument Company, there are three classes of motors used:

1. For the operation of charts and recording instruments, the Telechron motor is used.

2. Small synchronous and induction motors in ratings from 1/50 to 1/20 h-p. are used for the main drive of mechanical potentiometer recorders and controllers. On the recording instruments, synchronous motors are used to drive both the mechanical balancing



C. J. Tagliabue Mfg. Co. Celectray pyrometer recorder-controller. The motor on the left-hand side is synchronous and drives the chart. The motor mounted at the lower right-hand corner is a reversible induction and drives the recorder pen.



Tag Celectray indicating controller. Close-up of throttling mechanism, which is gear and cam driven from Bodine Type K capacitor start and run induction motor.

system and the chart. On the non-recording instruments, induction motors, and occasionally d-c. motors, are used to drive the balancing mechanism. In the case of the simpler controllers, a single, slightly larger motor, is frequently used to drive as many as six separate controllers. A maximum of 1/10 h-p. is required where six controllers are operated together.

3. Motors used to operate electric motor-operated valves. These range widely in size and characteristics, depending upon the type of valve service. These motors are usually induction, with occasionally a d.c. motor where alternating current is not available.

This manufacturer states that low-inertia motors and reversible variable-speed motors with high torque output and brushless construction are other types of motor drives which are of interest.

The Automatic Temperature Control Co., Inc., who manufacture a variety of apparatus serving the purposes of combustion control and process control, use several types of motors. For their timing controls they find the hysteresis synchronous type of small motor satisfactory for the majority of applications. For their line of motor-operated valves they require a wide variety of motors, ranging from totally-enclosed universal series wound units rated approximately 1/20 h-p., up to totally-enclosed or explosion-proof capacitor start-and-run ball-bearing motors in small fractional sizes. Some of the motors used for valve operators are Holtzer Cabot totally-enclosed gear reducer units in approximately a 2⅝" O.D. square frame.

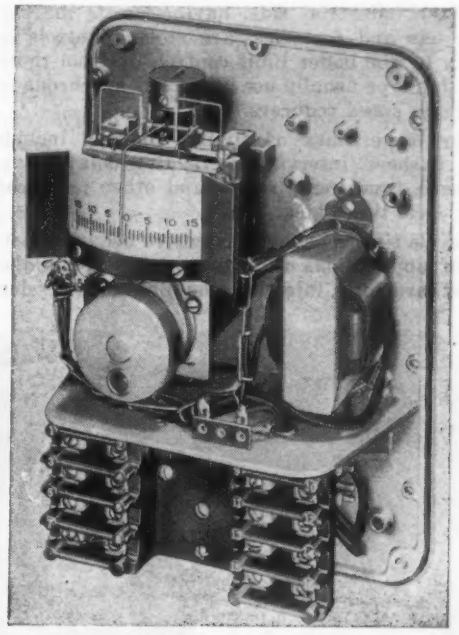
A wide variety of valve operators are produced, which require a corresponding variety of motor ratings and types.

The temperature control instruments manufactured by Wheelco Instrument Co. are confined to indicating and controlling types. As no recorders are manufactured, their motor requirements are limited to hysteresis synchronous motors, which are used to operate program controllers, chart drives, proportioning controllers and other similar uses.

A typical application of the hysteresis motor to a galvanometer relay used for temperature and other forms of control, very often in conjunction with Wheatstone bridge circuits, is provided in the unit manufactured by G-M Laboratories, Inc. This is shown in the accompanying illustration.

2. Timing Mechanisms

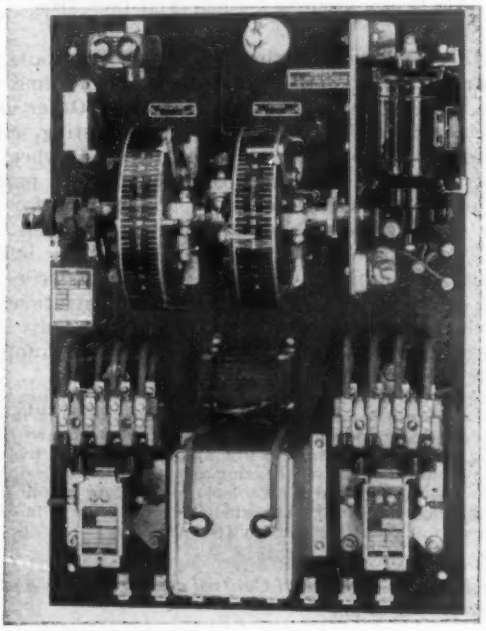
One of the most interesting applications of a motor to a timing device is provided in the example of the Square D Co.'s welding time controller. The apparatus is shown in the accompanying illustration. The motor drives a camshaft which operates a series of electrical contacts, which may be adjusted to open and close at various points during each revolution of the camshaft. The motor is brought to a quick stop within a few cycles by means of a capacitor and reactor connected across the motor terminals, thus securing a



G-M Laboratories, Inc. Type 780 supersensitive galvanometer relay. Utilizes a hysteresis synchronous motor for operating the depresser bar mechanism.

form of dynamic braking. The motor used is a Bodine Type N12R synchronous ball-bearing unit with a 6 to 1 integral speed reducer, rated approximately 1/75 h-p. at 1800 r.p.m.

Damper control motors are a type that have been applied



Square D Company, Industrial Controller Division, spot-weld timer with synchronous motor drive.

by the thousands for combustion control of household heating furnaces and for other general-purpose use on small combustion control apparatus. There are a considerable number of manufacturers who make units of this type, such as White Mfg. Co., Minneapolis, Barber Colman Co., Penn

Electric Switch Co., Automatic Products Co., to mention only a few. The motors used in these units are usually of the two-pole shaded-pole variety, with rectangular cores and form wound coils, and are usually enclosed in dust-proof housings which also protect the necessary reduction gearing.

Similar in general field of application, though somewhat more on the industrial side, having as its market apartments, hotels and factories, are stoker controls governed frequently by the boiler limit control, or from thermostats. Units of this type usually use hysteresis synchronous motors with integral speed reducers.

Another large class of timing controls includes time switches, flashers, interval timers, time-delay relays, work cycle timers, time count relays and other modifications of the work cycle timer idea.

Work cycle timers have an extensive use in industry for a variety of applications in connection with induction heating, flame hardening, injection moulding, compression moulding, and for such work as timing multiple drill units to prevent starting of all of the motors at the same time, and to obtain a dwell at the end of the work cycle. Other uses are for electronic heating, automatic sand blasting, chemical proportioning pumps, dust collectors, grinding wheel dressing control, indexing and feed control, and feed pumps.

The Monitor Controller Company Work Cycle Timer.

Anything like a complete list of applications for timing controls of one type or another could go on almost indefinitely. These timing devices generally use the hysteresis type synchronous motor with built-in speed reducer. Examples are shown in several accompanying illustrations.

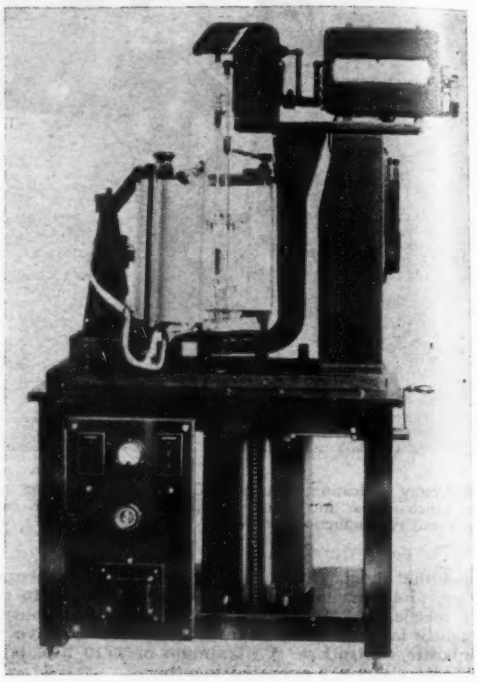
The chief engineer of one prominent company has the following comments to make regarding motors applied to their timing devices:

> The greatest proportions of failures in service are due to motor failures, and most of these difficulties are due to loss of lubricants. Features which we would like to have in motors are improved ways and means which will insure ample lubrication over longer periods of time and better bearing construction, especially with regard to the output shafts. We look forward to motor improvements, especially in those sizes which develop from 8 in.-oz. to 60 in.-oz. torque at from 1 r.p.m. to 10 r.p.m.

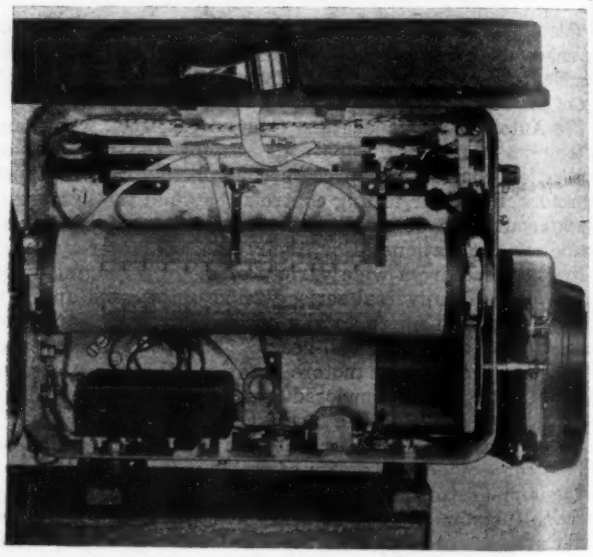
8. Miscellaneous Industrial Control and Scientific Apparatus Motor Applications

In addition to the Bristol Co.'s use of hysteresis synchronous motors for chart drives and small-size capacitor induction motors for potentiometer drives, they also use a basic recording instrument on their Dilatometer, illustrated herewith, which records temperature-dilation changes and temperature-time changes simultaneously on a chart during heating and cooling cycles of ferrous and non-ferrous metals, ceramics, and many other materials in solid form which expand and contract upon heating and cooling. Such instruments are used for determination of the composition of steel by the shape of the curve produced. These units use synchronous motors on the chart drive and capacitor induction reversible motors to operate the slide wire contact arm and pen.

An example of specialized instrument application is provided by the Consolidated Engineering Corp., who have three types of instruments, all of which use motors. Their vibration instruments use a 12-volt d-c. motor for driving the chart on portable instruments. They also use a timing motor, which is oscillator controlled, for locating time indications on the chart.



The Bristol Company. Dilatometer, using standard potentiometer slide-wire recorder.



The Bristol Company. Close-up of recorder used on Dilatometer, showing drive motors.

The mass spectrometer is a very large and expensive machine which uses a hysteresis synchronous motor for the chart drive, another timing motor for locating time points on the chart, and a ¼-h-p. induction motor for operating the blower for cooling vacuum tubes in the control cabinet.

Continued on page 414

ELECTRIC GAGING METHODS
for Strain, Movement, Pressure and Vibration

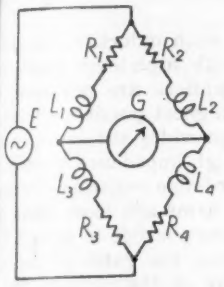
By HOWARD C. ROBERTS, Research Staff, Association of American Railroads, Chicago, Ill.

X. BRIDGE CIRCUITS.
(Continued)

§3. BRIDGE CIRCUITS FOR INDUCTANCE MEASUREMENT.

In the measurement of inductance values with bridge circuits, the general requirements imposed upon the circuit are the same as those described for capacitance bridge circuits. Some of the circuits described in the preceding section can be used equally well for inductance measurement.

Although good quality capacitors may be considered (in all but the most precise work) as possessing reactance without ohmic resistance, it is not physically possible to construct inductors without resistance components, and in practice it is not uncommon for the ohmic resistance of an inductor to be of the same order of magnitude as its reactance. For satisfactory measurement of the inductance of such an element it is quite essential that both reactance and resistance adjustments be available in the bridge circuit.



$$\frac{R_1+j\omega L_1}{R_2+j\omega L_2}=\frac{R_3+j\omega L_3}{R_4+j\omega L_4}$$

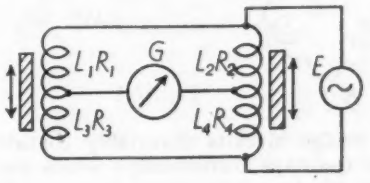
$$\frac{R_1}{R_2}=\frac{R_3}{R_4}=\frac{L_1}{L_2}=\frac{L_3}{L_4}$$

FIG. 150

The four-arm inductance bridge (corresponding to the Wheatstone resistance bridge circuit of Fig. 137) is shown in Fig. 150. Resistance as well as inductance necessarily occurs in all four arms of the circuit. The balance equations are as shown. Perfect balance requires that the ratios of resistance and reactance all be equal. This requirement does not introduce appreciable difficulty in constructing fixed inductance elements, since it is easy to control the resistance, and it is necessary only to bring corresponding inductors to definite values which need not be definitely related to the inductance value. It is possible, therefore, to adjust impedances by means of series resistors.

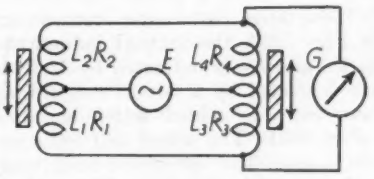
With variable-inductance gaging elements, however, difficulties may occur when operation of the device causes change in inductance of the primary element without causing corresponding change in resistance. Because of their wide application in gaging practice, in which they appear in several different forms, the most common circuits of this type will be described separately. Since ohmic resistance is always present, there is no occasion to describe any circuit not containing resistance.

Perhaps the best known paraphrase of the circuit of Fig. 150 is the induction balance widely used for remote indication of instrument positions. (Refer to Fig. 57.) This device, as ordinarily constructed, is a symmetrical four-arm inductance bridge circuit comprising two inductance-ratio type primary elements. In the diagram of Fig. 151A, the source of electric energy is indicated by E, and the position of the detector, if any is used, by G. It should be noted that the subscripts here refer to the same relative positions as in Fig. 137. In this configuration, as the two armatures move upward, both L_1 and L_2 increase, and L_3 and L_4 decrease, so that L_1/L_2 may continuously equal L_3/L_4, and they may be made to assume any convenient value. If an initial resistance balance is made, perfect balance for both inductance and resistance is possible over a wide range of armature positions. For example, let all the resistance



$$\frac{R_1}{R_2}=\frac{R_3}{R_4}=\frac{L_1}{L_2}=\frac{L_3}{L_4}$$

FIG. 151 A



$$\frac{R_1}{R_2}=\frac{R_3}{R_4}\;;\;\frac{L_1}{L_2}=\frac{L_3}{L_4}$$

BUT $\frac{R_1}{R_2}\neq\frac{L_1}{L_2}$

FIG. 151 B

values be equal, so that R_1/R_2 and R_3/R_4 both equal 1; it is likewise possible to insure that L_1/L_2 and L_3/L_4 also equal 1, and balance is thus accomplished for both resistance and inductance.

But in the conjugate circuit,* drawn in Fig. 151B, while the same requirements for balance are imposed, the different configuration produces a different behavior. Here perfect balance both to resistance and to inductance is possible at only one position of the armatures. If the resistance ratios are adjusted to unity, perfect balance is attained only when the inductance ratios are also unity—which is possible only when the armatures are at their mid-positions. At all other positions of the armatures, only a minimum output (not a true null point) can be secured; for many applications, of course, such a minimum can be used satisfactorily. This rather astonishing result is more easily understood through a study of the general solution given in Fig. 150; it may be seen that Fig. 151A represents a special case.

A common modification of the induction balance was shown in Fig. 58 and was described as a position-relaying system. The circuit, redrawn and with its balance equations, is shown in Fig. 152. It is often known as the Maxwell inductance bridge circuit, and it is one of the oldest circuits known for measurement of self-inductance. Again, perfect

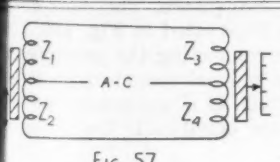


FIG. 57

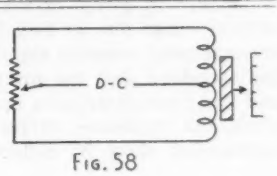
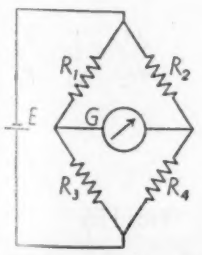


FIG. 58



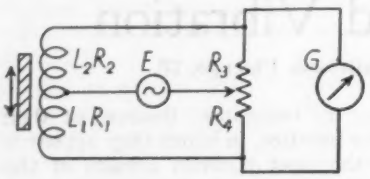
$$\frac{R_1}{R_2}=\frac{R_3}{R_4}\;;\;R_4=\frac{R_2R_3}{R_1}$$

FIG. 137

These diagrams from previous instalments of Mr. Roberts' serial, are referred to in this month's instalment and are reprinted for the convenience of the readers.

*The conjugate bridge circuit is that produced when the positions of the source and the detector are interchanged. In the general case, if the circuit is once balanced, such an interchange will not destroy the balance, although it may change the sensitivity of the circuit.

balance requires simultaneous reactance and resistance adjustment. Either the circuit as drawn in Fig 152, or its



$$\frac{R_1+j\omega L_1}{R_2+j\omega L_2}=\frac{R_3+j\omega L_3}{R_4+j\omega L_4}$$

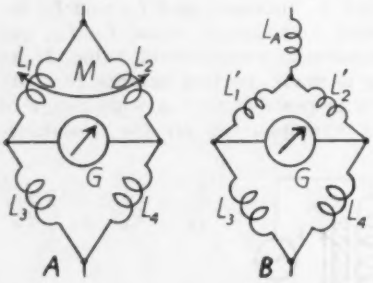
$$\frac{R_1}{R_2}=\frac{R_3}{R_4}=\frac{L_1}{L_2}$$

FIG. 152

conjugate, can be used. The balancing adjustments are somewhat tedious.

The position-repeating device shown in Fig. 58 does not provide for continuous adjustment of the resistance balance, so that the output of the circuit is not zero, but a minimum.

In their normal applications, the three circuits described above are self-balancing—movement at one point of adjustment is matched by movement at the opposite end through the transmitted electric energy. The same balance conditions apply, whether the system is self-balancing or manually balanced. The only difference is in sensitivity and consequent accuracy of balance.

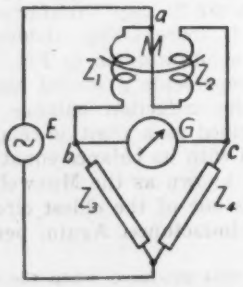


ELEMENT	OPERATOR
L_1	$j\omega L_1$
M	$j\omega M$
L_A	$-j\omega M$
L_1'	$j\omega M+j\omega L_1$
L_2'	$j\omega M+j\omega L_2$

FIG. 153

Practical inductance bridge circuits invariably contain some mutual inductance (perhaps fortuitously) which can occasionally play an important part in circuit response. It is possible mathematically to resolve a circuit containing both mutual and self inductance into one containing only self-inductances. In Fig. 153A the mutual inductance between the two elements L_1 and L_2 is indicated by M. The same electrical response is provided by a circuit containing no mutual inductance but with an added self-inductance element L_A as drawn in Fig. 153B. The added self-inductor appears in series with the source. The operators describing the circuit elements are also listed in Fig. 153. The mathematical demonstration is beyond the scope of this work, but an appreciation of the fact will aid understanding of other circuits to be discussed.

A more interesting—and in gaging practice more useful—application of mutual inductance is the use of inductive ratio arms in conjunction with variable-impedance primary elements of almost any form. Here a pair of circuit elements are deliberately coupled through mutual inductance, and ordinarily the coupling is made as close as possible. (The best method of preparing such a coupled pair of circuit elements is by winding a selected core with two parallel strands of wire, so that corresponding turns of wire link the same flux lines.)



$$Z_1=R_1+j\omega L_1$$

$$Z_2=R_2+j\omega L_2$$

$$\frac{R_1+j\omega(L_1+M)}{R_2+j\omega(L_2+M)}=\frac{Z_3}{Z_4}$$

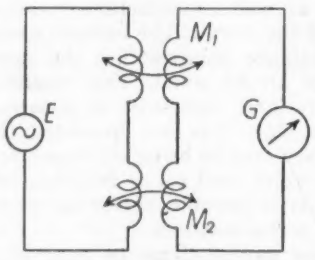
FIG. 154

A circuit containing such a pair of closely-coupled ratio arms is drawn in Fig. 154, with the polarity of the connections indicated. The two inductive elements are Z_1 and Z_2, and are considered to be closely coupled through a mutual inductance M. The other two arms of the circuit, Z_3 and Z_4, may be any form of impedance element. By reason of the close coupling, if equal currents flow through the two coils Z_1 and Z_2, their fields counteract, and the potentials at the three points a, b, and c are very nearly equal; almost the entire source potential appears across Z_3 and Z_4. But if the currents are not equal, their fields do not exactly counteract each other and the resulting unbalance potential is large—as large, in fact, as though high-impedance series inductance arms were used in the circuit.

Mutual-inductance ratio arms have several advantages. The apparatus is more compact and more sensitive than the corresponding circuit employing only self-inductance elements, and it is less subject to external disturbances. Because of the high degree of symmetry and the close coupling between the ratio arms, there is little stray-capacitance effect.

The symmetrical bridge circuit with inductive ratio arms is especially desirable for use with high-level gages used without amplification. When amplifiers are not used, the system must be designed for the highest possible efficiency; the use of inductive ratio arms provides the same voltage sensitivity as would a pair of high-impedance circuit elements while not introducing appreciable resistance losses.

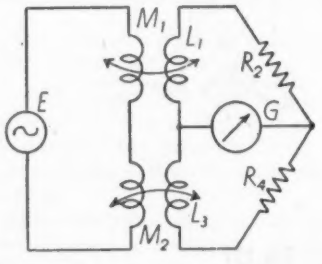
Although these inductive ratio arms are most often constructed with unity ratio, it is quite possible to design them for other ratios. In any such unit, the ratio of the self-inductances must equal the square of the ratio of the resistances, and the coupling must be as close as possible.



$$M_1=M_2$$

FIG. 155

A number of circuits have been developed for the comparison of mutual inductance values, or the measurement of impedance in terms of mutual inductance. The most direct method—that due to Felici—is illustrated in Fig. 155. This arrangement consists simply in connecting the primaries of the standard and the unknown mutual inductors in series and their secondaries in opposition. It is apparent that only when the opposing currents are equal will the detecting instrument show no deflection.



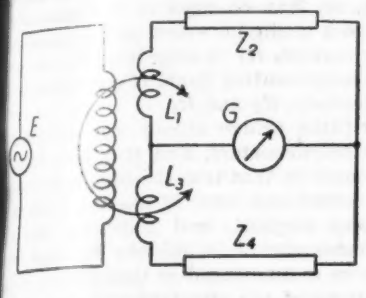
$$\frac{M_1}{M_2}=\frac{L_1}{L_3}=\frac{R_2}{R_4}$$

FIG. 156

The Felici circuit has been converted into a mutual-inductance bridge circuit by Maxwell, taking the form of Fig. 156. As ordinarily used, the ohmic resistances of the inductors are low, but if they are so large as not to be

This instalment of H. C. Roberts' serial, together with last month's instalment, constitutes one of the most valuable references on a-c. bridge circuits ever printed anywhere. Owing to the paper shortage, single copies of *Instruments* are not sold and back copies cannot be furnished.—MFB

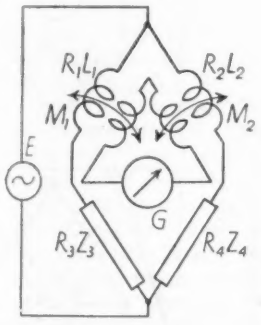
ligible—which is nearly always the case—they must be justed to correspond to the self-inductance values of L_1 L_2.



$$\frac{L_1}{L_3} = 1 = \frac{Z_2}{Z_4}$$

FIG. 157

While Maxwell's mutual inductance bridge circuit is signed for the comparison of two separate mutual-inductce elements, the circuit itself may easily be converted into form which is most useful for comparison or measureent of impedance elements of other types. In Fig. 157 a rcuit is drawn including a differential transformer—metimes termed a hybrid coil. This device contains three ndings closely coupled together, two of them exactly tched and similarly coupled to the third. The construction such that the mutual inductances, the self-inductances, d the ohmic resistances of the two secondary windings are ual; under these circumstances when the impedances Z_3 d Z_4 are equal in magnitude and in phase angle the out- t of the circuit is zero. The device is extremely simple in e, sensitive as well as robust and accurate.

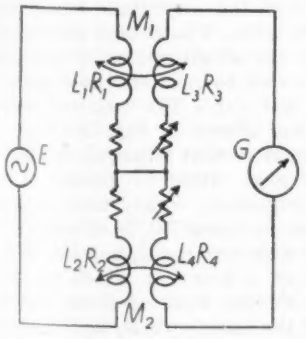


$$\frac{L_1}{L_2} = \frac{R_1}{R_2} = \frac{R_3}{R_4}$$

$$\frac{M_1}{M_2} = \frac{Z_3}{Z_4}$$

FIG. 158

Only slightly different from the differential-transformer rcuit is the Campbell mutual inductance bridge, drawn in ig. 158. In it the mutual-inductor secondaries are so conected as to inject equal and opposite voltages into the tector circuit at balance. It is necessary to establish an itial balance for resistance and for self-inductance of the imaries, as indicated in the first of the two balance equaons; then the secondaries are connected into the detector rcuit, when the second of the two balance equations applies.



$$\frac{L_1}{L_2} = \frac{L_3}{L_4} = \frac{R_1}{R_2} = \frac{R_3}{R_4}$$

$$M_1 = M_2$$

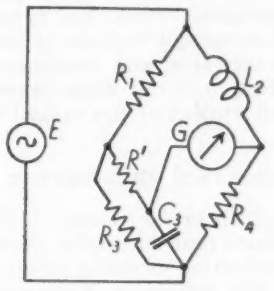
FIG. 159

Another mutual-inductance bridge circuit (Hartshorn's) s also adaptable to gaging practice. This circuit (Fig. 159) is especially suited to quite impure mutual inductance elements—those having a large resistance component. Resistance balance adjustment is available through the variable-resistance element coupling the common points of the two mutual inductance units; after the initial resistance balance adjustment is made this need not be altered.

All the mutual-inductance circuits listed here can be used in deflection methods as well as in null methods. They can be constructed with low ohmic resistance, and with consequent high efficiency. They may be applied to many gaging problems to which mutual-inductance primary elements can be applied.

A large number of bridge circuits have been devised for the measurement of inductance values in terms of capacitance and resistance; the list includes almost every possible configuration. Three representative circuits will suffice to illustrate the principles involved; the three are the Anderson, the Owen, and the Hay circuits.

The Anderson circuit was developed specifically to reduce or eliminate the tedious and confusing adjustments required by some of the older ballistic bridge circuits; it possesses an extra pair of impedance elements, so that in the practical form there are six circuit elements which may be adjusted if desired. The method is a powerful one, and it has been applied to many measuring circuits.



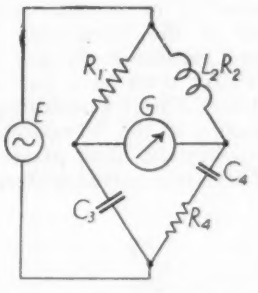
$$\frac{R_1}{R_2} = \frac{R_3}{R_4}$$

$$L_2 = C_3 R_4 [R'(1 + R_1/R_3) + R_1]$$

FIG. 160

In Fig. 160 the Anderson bridge circuit is drawn; as will be seen, it has its inductive branch balanced by an opposite branch containing both resistance and capacitance. (It may be pointed out that the ballistic prototype circuit from which the Anderson circuit was developed differs only in not containing R'.) The two balance conditions are described by the two equations given in the figure; they are not entirely independent, but if the second equation is fulfilled before the first is attempted there is no interference between adjustments. The actual inductance value may be computed from the second equation given with the figure. This circuit has an extremely wide range, through adjustment of the value of R'; but the greatest sensitivity is obtained only when the values of the circuit arms are so selected as to make it an equal-ratio bridge circuit.

The Owen bridge circuit is one which makes possible the measurement of inductance values in terms of capacitance,



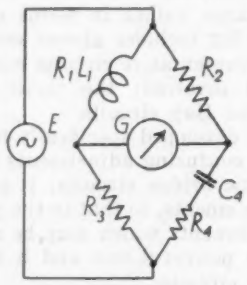
$$R_1 C_3 = R_2 C_4 = L_2 / R_4$$

FIG. 161

but which does not depend for high sensitivity so greatly upon the circuit ratio as does the Anderson circuit. The Owen circuit is drawn in Fig. 161; it is a four-arm bridge circuit in which the phase angle of the inductance arm is balanced by the difference in phase angles of a capacitor and a capacitor and resistor in series. The Owen circuit is one of the easiest to use, since the two balance conditions are entirely independent, so that adjustments may be made in any order. The circuit is not frequency-sensitive, and may be used with impure sources of alternating current.

Difficulty is occasionally experienced in the measurement of inductance values of elements having large resistive com-

ponents; the adjustment for phase balance requires more attention than for the measurement of nearly-pure reactances, and the possible errors are greater. The Hay bridge is capable of phase adjustment over a range sufficient to take care of all ordinary circuit components. The unknown element, containing both inductance and resistance, is placed opposite an adjustable arm containing both capacitance and resistance, and if the frequency of the exciting



$$L_1 = R_2/\omega R_4 C_4$$

FIG. 162

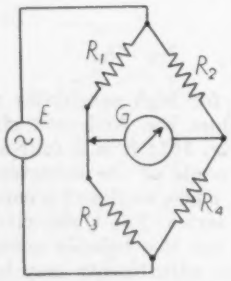
energy is maintained constant the balance may be made perfect over wide ranges of impedance values. The circuit is drawn in Fig. 162. The exciting current must be of constant frequency and of good wave-form, and precautions must be taken against the effect of stray capacitances, which might affect the phase adjustment of the capacitive arm of the circuit.

§4. Bridge Circuits for Resistance Measurement.

Undoubtedly the best known of all bridge circuits is the Wheatstone network, which contains four adjustable resistance elements, and two other conducting elements comprising the source of energy and the indicating instrument. This network, with its equations of balance, was given in Fig. 137. The balance equations may be written in any other convenient form.

The Wheatstone network, like all of the generalized forms, operates equally well in its conjugate connection, although in general the sensitivity will be higher in one than in the other connection. If an equal-ratio bridge circuit is used, the sensitivity is the same in both connections; if two of the impedance arms have greater magnitudes than the other two, the greatest sensitivity is obtained when the detecting instrument is connected between the junction of the two arms having the greater resistance and the junction of the two arms having the lesser resistance. (It is assumed that the resistance of the detector is greater than that of the battery.) The most efficient transfer of energy is secured when the imperances of all six branches of the network are equal.

The resistance bridge circuits most used in gaging practice—especially with strain-sensitive or pressure-sensitive primary elements—are usually of the Wheatstone form. Because of the extremely small resistance changes which occur in these elements, the circuit must have high sensitivity and high stability. The Carey-Foster modification and the Callendar-Griffiths modification of the Wheatstone circuit have both had a wide application. Both attain high sensitivity through the use of sensitive galvanometers, and



$$\frac{R_1}{R_2} = \frac{R_3}{R_4}$$

FIG. 163

both limit the operating range (and at the same time increase the precision by which the scale can be marked off) by using a slide-wire as the adjustable element in series with fixed resistors of large magnitude. The circuit is drawn in Fig. 163. It will be noted that the slide-wire connects R_1 and R_3, and a portion of its resistance is included in each of these. The indicating instrument is attached to the moving contact, so that changes in the resistance of this contact will have a negligible effect on the operation of the circuit. In this diagram, R_4 is considered the unknown, R_2 the reference or compensating gage. If a resistance-ratio element is used, it replaces R_2 and R_4.

The Callendar-Griffiths bridge circuit was designed for use with resistance thermometers, and it differs from the diagram (Fig. 163) only in that into the compensating arm a pair of leads are introduced, exactly like the leads to the resistance-thermometer element, and following the same route. The Carey-Foster circuit is like the drawing except that a switching device is introduced so that after a balance is attained the positions of the standard and the unknown can be interchanged; this interchange makes it possible to balance out lead resistances to a high degree of accuracy. In gaging practice this refinement is seldom justified, since the required measurement is one of small *changes* in resistance.

Certain practical bridge circuits contain features slightly different from those just described, introduced entirely for convenience in use. For example, when a series of resistance-type gages are installed, all to be read on the same bridge

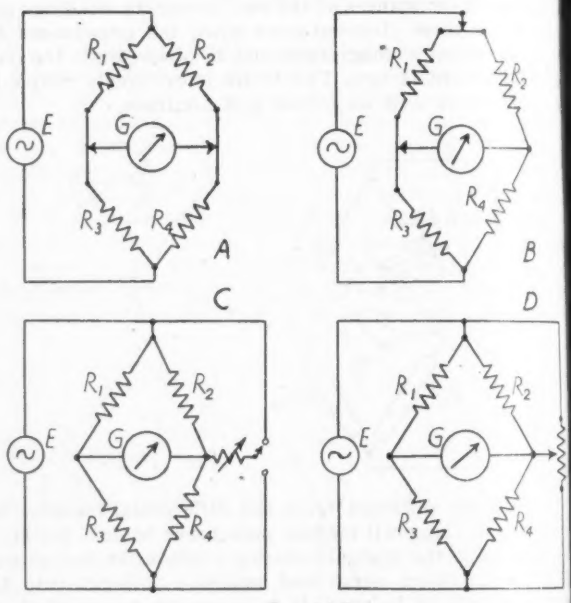


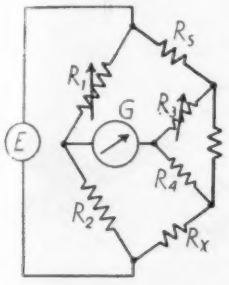
FIG. 164

circuit, much time and trouble will be saved if there is available some means of "setting" the circuit for each gage so that a direct-reading scale can be applied. One such means is by the use of two slide-wires in the circuit, one graduated directly in units of the magnitude being measured, the other in arbitrary units. The second slide-wire is used to adjust the circuit to the initial setting of each gage, while the first slide-wire is used to read off the changes in resistance experienced by that gage. The required connections for this application are shown in Fig. 164A. A disadvantage of the arrangement is that it prohibits the connection of one end of any gage either to ground or to a common lead. Another arrangement, widely used, and providing the same convenience in operation, is drawn as Fig. 164B; in it a second slide-wire (or multiple-point switch) is used, but it is located at a point at which energy is introduced into the bridge circuit. Both of these, however, are simple modifications of the basic circuit, and their performance is described by the same equations previously given.

As a means of increasing the length of the graduated scale on such an instrument, another expedient has been employed occasionally—the so-called shunt bridge circuit. In this circuit small changes in the effective value of one of the adjustable arms of the bridge are produced by shunting

the resistor with an adjustable resistance element of high value. This adjustable resistance element may be a rheostat, in which a switch must be installed to shift it into the branch in which it is needed, or it may be a voltage divider, placed in parallel with two adjacent arms of the bridge circuit. Again the actual behavior of the circuit is just as described previously. These two modifications are illustrated in Fig. 164C and Fig. 164D.

The Kelvin or Thomson bridge circuit, comprising nine conducting elements, with six impedance arms, possesses great advantages over the Wheatstone form for certain applications. If the unknown resistance is low enough to be comparable to the lead resistances, for example, the Wheatstone circuit becomes almost useless; it is in this range that the Kelvin bridge circuit operates best. And in some mechanical applications—as where it is necessary to make connections to a moving part through slip-rings and moving brushes—the Kelvin circuit is often preferable to the Wheatstone.



$$\frac{R_1}{R_2} = \frac{R_X}{R_S} = \frac{R_3}{R_4}$$

FIG. 165

The Kelvin bridge circuit is drawn in Fig. 165. It contains four high-resistance impedance elements, between the midpoints of which the indicating instrument is connected. The standard and the unknown resistors are connected in series with a source of current of considerable magnitude. The high sensitivity of this circuit for measuring resistance values of the order of 0.001 ohm depends entirely upon the presence of a heavy current through these resistors. The balance equations are given in Fig. 165 also.

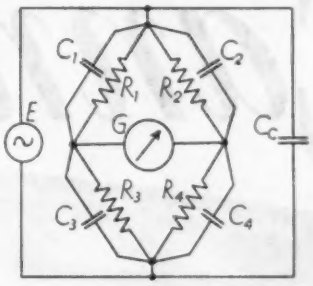
Since the accuracy of the circuit does not depend upon the magnitude of the current employed—although the sensitivity does—and since the ratio arms R_1, R_2, R_3, and R_4 are all of high resistance, the effect of variable-resistance contacts in the leads to the primary elements is small. It therefore is possible to employ brushes and slip-rings effectively with the Kelvin circuit in situations in which the Wheatstone circuit would be quite unusable. It is a fortunate circumstance that the Kelvin circuit is most conveniently used when the resistances of R_X and R_S—the unknown and the standard—are nearly equal; in gaging practice that is a typical condition.

The circuits just described—see Figs. 137, 163, 164, and 165—are ordinarily used with direct current as exciting energy. They can also be used with alternating current, with a suitable indicating instrument. But if a-c. excitation is used, consideration must then be given to the reactances of the circuit elements, which have not yet been mentioned in this section.

Resistance-type primary elements may usually be so constructed as to possess negligible inductance, and with small capacitance within the element itself. But in the lead wires connecting the primary element to the measuring instruments, there may well be sufficient capacitance between wires and to ground to destroy entirely the balance of the system. Unless the frequency of excitation is quite low (so that the impedance values of these capacitances are negligible when in shunt with the resistances) capacitance balance will be required.

In Fig. 166 is drawn the system of first-order capacitances occurring in a four-arm bridge circuit connected through four wires to the energy source and to the detector. Second and higher order effects can almost always be ignored. The balance equation, given in Fig. 166, indicates that the capacitance values must also be adjusted if the circuit is to be balanced for alternating current.

The same effect appears with any other resistance bridge circuit when it is excited with alternating current. Analysis



$$\frac{R_1}{R_2} = \frac{R_3}{R_4} = \frac{C_1}{C_2} = \frac{C_3}{C_4}$$

$$\phi = \arctan \omega CR$$

FIG. 166

of such circuits is facilitated by the use of the phase-angle concept; the phase shift for corresponding circuit elements must be equal. The value for ϕ, the phase angle, is defined in Fig. 166 for circuits containing resistance and capacitance in parallel.

The capacitance C_C in Fig. 166 does not affect the bridge circuit in terms of its balance; it merely shunts the source and therefore absorbs some of the exciting energy.

§5. Deflection Bridge Circuits.

Virtually any bridge circuit which can be used in a null method can also be used in a deflection method. The difference is one of application, not design.

In practice, the most satisfactory method for arriving at the calibration for a deflection bridge circuit is through actual trial. It is an easy matter, however, to compute approximate values for the output potential or current, if an approximation is permitted, as regards potential.

Over a small range—usually more than sufficient for the small changes in resistance experienced by resistance-type gaging elements excepting the slide-wire types—the output potential of a Wheatstone bridge circuit is proportional to the percentage resistance change in the unknown. Or, it is very nearly equal to one-fourth this resistance change, in percent, multiplied by the exciting potential. If a resistance-ratio element is used, the value is doubled, since equal and opposite changes appear in two adjacent impedance arms of the bridge circuit. This simple relation may be used to compute the approximate potential output from most of the bridge circuits described in the preceding section.

A method depending upon Thévenin's theorem affords a simple means of computing the current output from such a circuit, once the potential output is known. Thévenin's theorem states that in any circuit, if any branch is opened and the potential measured across the open ends, the current which flowed through that branch equals that which would flow if all other sources of potential were removed, and a source equal to the measured potential difference inserted in the broken branch. As an example: in Fig. 137, let the galvanometer branch be broken, and the potential difference there be measured, then remove the source of exciting energy E, replacing it with a resistance element of the same resistance magnitude, and insert in the broken galvanometer branch a source of potential equal to the potential measured there. The current then flowing is equal to the original current. In effect, all that is needed is the potential output value, and the circuit resistance measured from the detector position, then the computation follows Ohm's law.

The theorem is applicable to any circuit of linear elements, and is extremely useful in circuit analysis.

§6. Frequency-sensitive Bridge Circuits.

Bridge circuits sensitive to frequency of excitation have a number of useful applications in addition to measurement of impedance values. Their frequency sensitivity is seldom an advantage in measurement of impedance values—it complicates the procedure, and introduces another possible source of error. But these circuits in other applications

Continued on page 410

Canned TO PRESI

Buy More War Bonds and Stamps

ERROR of a ten thousandth of an inch in the directional gyro might throw a plane far off its course—lose it and all its occupants. Yet such delicate and precise instruments must make long, rough journeys to a war half way around the world —and wait months perhaps before seeing service.

Not satisfied with designing and producing the finest of aircraft equipment, Jack & Heintz engineers were determined to protect it from dirt, dust, moisture, shock—any factor that might destroy its fine accuracy. Working with the Packaging Container Division and the Engineering Division of the Air Technical Service Command, they developed a revolutionary new means of packaging—literally "canning"—to preserve precision.

Precision instruments, starters and generators are floated in rubber-impregnated hair cushion or pulp castings in the can. Silica gel is included to absorb all inside moisture. Then a special J. & H. developed machine clinches the cover to form an

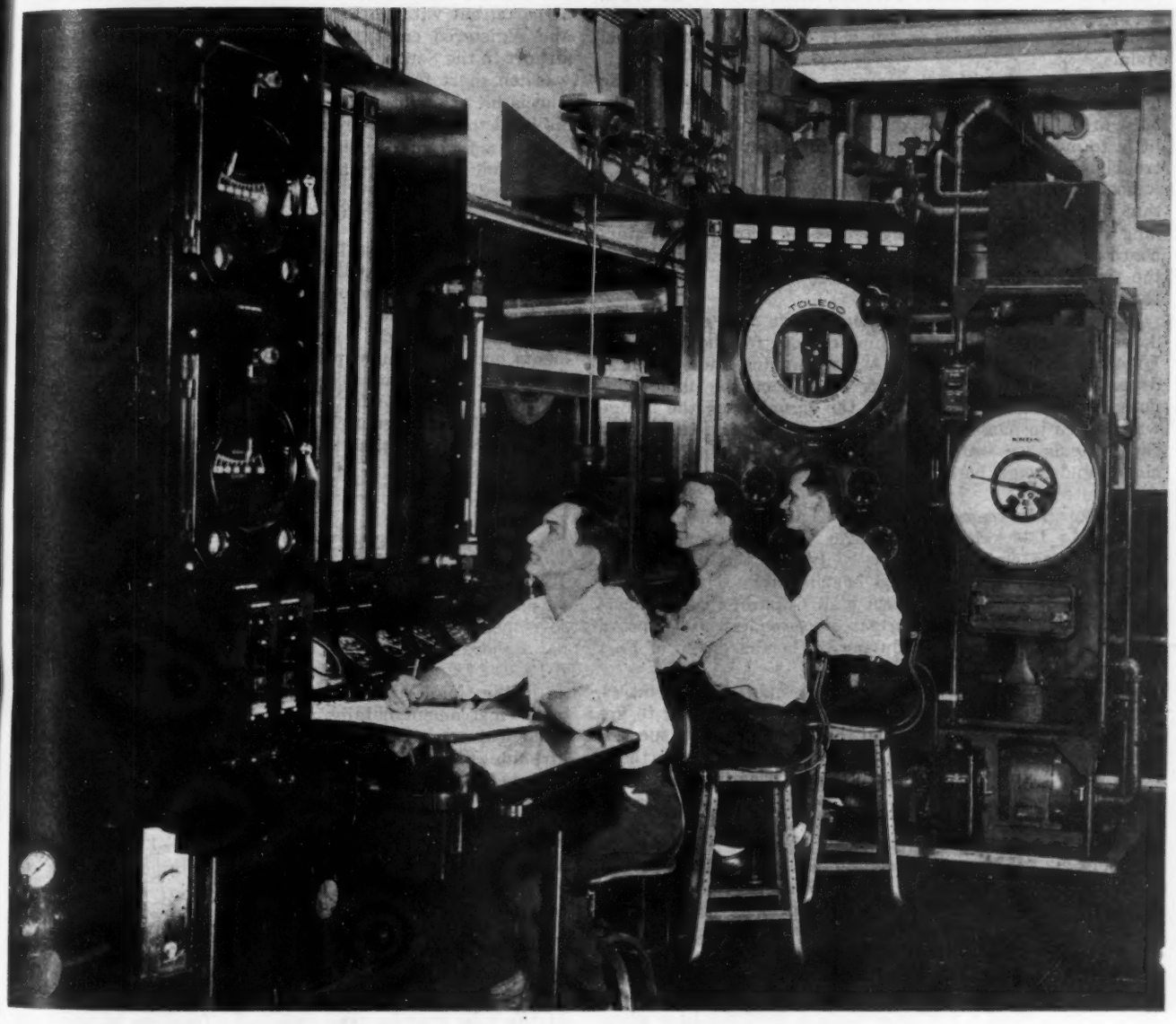
Jack & Heintz Inc., Cleveland, Ohio, manufacturers of aircraft engine starters, generators,

APPLICATIONS OPERATING PRINCIPLES INSTALLATION MAINTENANCE

Aviation Instruments

Navigation Automatic-piloting Power plant Automatic-landing Aerological
Communication Flight-testing Production Instrument-testing

Vol. IV, No. 6 M. F. Béhar, Editor June 1945



Automatically-controlled Dynamometers Facilitate Engine Testing

By GUY BARTLETT, General Electric Co., Schenectady, N. Y.

BECAUSE of important advances in automatic control of dynamometers, installations will be outstandingly effective if the electrical machines best suited to the task are selected and if they then are controlled to do exactly the work required. By manipulating a few small dial-type rheostats, the testing operators establish the conditions under which they wish the dynamometer to operate. Thereafter the automatic controls make the dynamometer follow the established requirements precisely and without attention, leaving the operators free for the work at hand, namely, testing. An example is the aircraft engine test shown in this photo: the engine is in the room seen through the observation window and the automatically-controlled dynamometer is in a room beyond the engine room.

"We Lived—A Veteran Pilot Died"

The VITAL Importance of Instruments

By WILLIAM TALLANT BRYAN, Instructor, Pioneer Instrument Service School, Philadelphia.

PART ONE

ON its flight to Africa the huge forty-two-ton four-engined Pan-American "Clipper" had just crossed the Equator. There were forty-nine persons on board: eleven crew members and thirty-eight on the ship's passenger list —which included high-ranking Army officers, diplomats, a scientist from the Rockefeller Foundation and his wife (the only woman on board), the celebrated writer Louis Fisher, executives of oil companies, diplomats of foreign governments, State Department couriers from the U. S. A., a group of Army Finance men, plus our group of Pan-American Airways mechanics on our way to bases in Africa and Asia.

Suddenly and without warning, above the ship's noise and vibration came that once-heard never-to-be-forgotten noise of the huge plane's hydraulic system working. It meant little to most of those aboard, but to a few of us it meant trouble.

Looking out of the port side lounge windows, I first saw that the landing flaps were still up and both engines running smoothly. Slipping easily across the lounge to the starboard side I saw the No. 4 outboard engine stopped with the "prop" in the feathered position. We were running on three engines!

Looking down 10,000 feet below there was nothing but dense, lush, South American jungle. Now, for the first time, I noticed dark clouds ahead. A few minutes later, the first drops of rain splashed in long streaks on the plane windows. At about the same time, the signal from the bridge was flashed to passengers to fasten safety belts. In another few seconds we were in the storm: pouring rain, black clouds and rough bumpy air all around us; visibility poor and limited.

The storm increased in intensity, but no one seemed concerned. As I look back today over that situation, I think everyone was confident of the ability of the man at the controls. His own confidential bearing seemed to carry to all on board. He was the crack pilot Captain Francis Scott Key Lewis (named after a great-great-uncle who composed The Star Spangled Banner during the bombardment of Fort McHenry).

As the huge ship fought its way through the storm, we became aware of the fact that the crew was trying to get out of it, or to go around it, and that they had little success. According to reports over the radio, the whole northern coast was experiencing the same kind of weather so we continued on to our objective.

As we neared the city of Belem on the Para River in Brazil, the storm abated somewhat, but fog closed in on the port as we were preparing to land. We circled about while the radio contact with the base told us to hold a position at 800 feet altitude. Fishing boats were cleared from the river in the area where we were to land and other preparations were made for us to come in.

We were not the only ship in the sky that ugly evening. There were two others, both land planes. They were to land on an airfield a few miles distant from the base where our "Clipper" was to land and were also experiencing difficulty. They were not in the trouble we were in, so were sent up to 2000 and 3000 feet respectively while we were held at our previously-mentioned 800 feet. When all was clear and in readiness we were brought in, to make a safe landing on the Para River in a fog under extremely difficult conditions.

Looking back again, we can be thankful for a good crew and a control panel full of well-adjusted instruments—instruments carefully serviced by men who were fully aware of the responsibility and the lives placed in their trust. Through carelessness or indifferent workmanship, we could have all lost our lives; but, we lived.

PART TWO

HE had forty-four missions to his credit, seven oak leaf clusters and two citations for his Distinguished Flying Cross. He and I became friends in Africa before he went up to the desert of North Africa to help chase Rommel back to his inglorious Germany. He carried the well-known writer, John Hersey, on the first bombing of Rome. Later he was sent to this country to train test pilots. While bringing a new ship and crew from Washington, D. C., he ran into stormy weather and tried several beams, from large airports, but with no success. The fuel gage went haywire and registered empty, so he decided to land at a certain airport in the South. He came in beautifully but the runway was too short for a "hot ship" like the B-26 and when the wheels hit the mud at the end of the cement the jolt caused his head to snap and broke his neck.

With a fuel gage registering properly he probably would have made a field with a longer runway.

CONCLUSION

THANKS to well-adjusted and carefully-overhauled instruments, we lived. Through some carelessness along the line, a veteran pilot died. Having lived with combat pilots in many parts of the world, I know their problems. The least we can do is to give them well-adjusted instruments on their control panel. Anyone working on aircraft flight mechanisms must be religious in his attention to detail; he must strive for perfection; he must never say, "I guess that's good enough"; and upon completion of every job he should ask himself, "Would I fly with that mechanism?"

Flying Weather by Psychrometer

FOR measuring temperature and humidity while an airplane is in flight, an aircraft psychrometer has been developed by the Meteorological Branch of Camp Evans Signal Laboratory. This instrument is now in active use on B-17, B-24 and B-25 bombers in many zones of operation as calibration equipment for aerograph instruments. The latter instrument obtains continuous records of the meteorological conditions of the atmosphere through which the airplane flies. The aircraft psychrometer has also been mounted on many types of aircraft for a variety of special research projects where accurate data on humidity and temperature are required. Operational plans of the Army Air Forces have been substantially aided and air campaigns furthered by weather reports obtained with the assistance of this device in regions which are inaccessible except by airplane.

Intensive experimentation was needed to bring the aircraft psychrometer to a degree of accuracy that made it practical. Mercury thermometers having their tubes bent at right angles are mounted so that the calibrated portion of the tube may be read inside the fuselage of the plane while the bulb of the thermometer extends outside into a streamlined ventilation duct. A careful study of all of the corrections involved, including that due to the speed of the air past the plane, has made it possible to determine the temperature and humidity quite accurately.

Used mostly on weather reconnaissance planes, the psychrometer, in combination with aerograph equipment, has made it possible to gather vital weather data over enemy territory so that accurate forecasts of weather to be expected over a military target may be made preliminary to take-off on combat missions. This information, supplementing weather data gathered by standard procedures, has

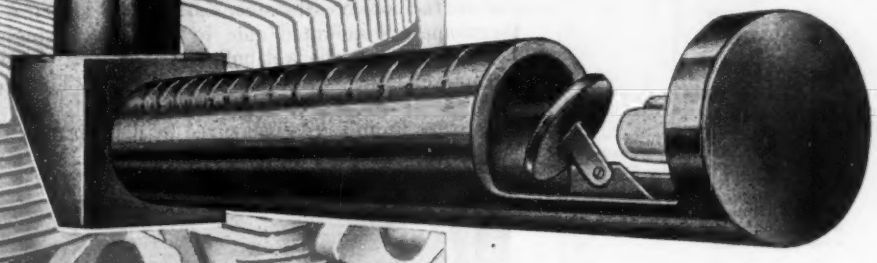
POLAN BORESCOPES

for the inspection of internal surfaces.....

Polan Borescopes are precision optical tools which magnify and bring into strong relief the characteristics of internal surfaces.

Requiring no special operator training, these inspection tools eliminate costly failures due to cracks, tool marks, porous areas, slack pits and other internal surface faults.

An inch graduation together with a clock dial at the eye piece determines the longitudinal and angular location of the internal surface fault.



Write today for your free copy of Borescope Bulletin No. 506.

ZENITH OPTICAL COMPANY *A unit of* **Polan** *Industries*

"the eyes of the allies"

makers of the precision eye for industry

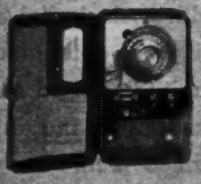
HUNTINGTON 19
WEST VIRGINIA

Paragon TIMERS*

"TAKE A LOAD OFF YOUR MIND!"

Paragon automatic electric controls go far toward eliminating the fallible human element. Simply preset a Paragon instrument to do what you want—then forget it. It will automatically start and stop machinery, air conditioning systems, and other operating equipment . . . in fact, perform a whole host of "almost human" time control operations.

A unit for every time control need



Series 300—General purpose, self-starting synchronous motor operated time switch, self-lubricating, for controlling signs, stokers, blowers, pumps and other purposes. Accurate, rugged.

Series 800—Instantaneous reset, synchronous motor operated, time-delay relay for motor and tube protection. Used to stagger the closure of multiple circuit systems so that full load will not be applied at start. Has wide application.

Series 700—7-Day synchronous motor operated switch for heating and ventilating systems, lighting and pumping in churches, schools, stores, factories, mines, etc. Can be preset weekly for a weekly schedule. Daily on and off operations may be independently set.

Series 2300—Manually preset interval timer, can be preset to perform a great variety of operations: to allow a given operation to continue for almost any predetermined time limit; and to close or open a circuit at the end of the preset time. Synchronous motor operated.

Many other types available. Write today for further information.

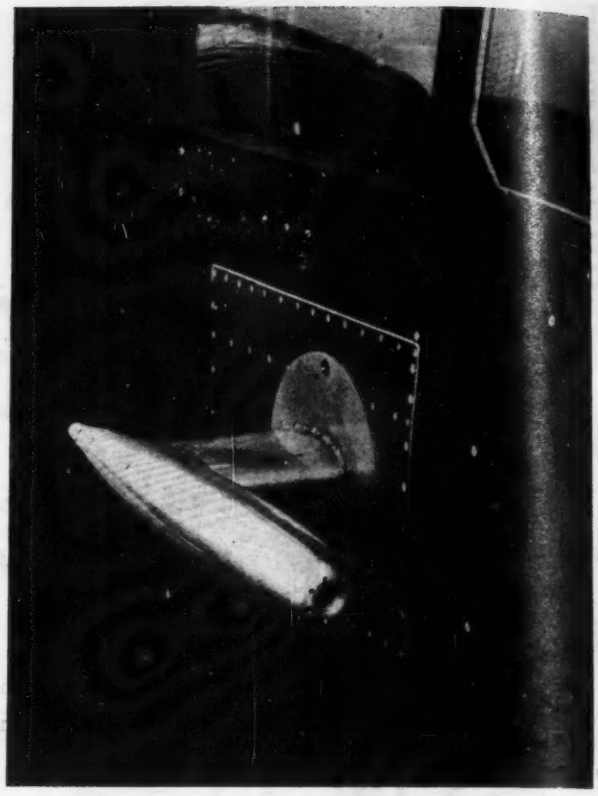
Mr. Tops, the Paragon Symbol of Top Quality.

Paragon Chicago

BUILDERS OF ELECTRICAL EQUIPMENT SINCE 1905

PARAGON ELECTRIC COMPANY

726 Old Colony Building, Chicago 5, Illinois

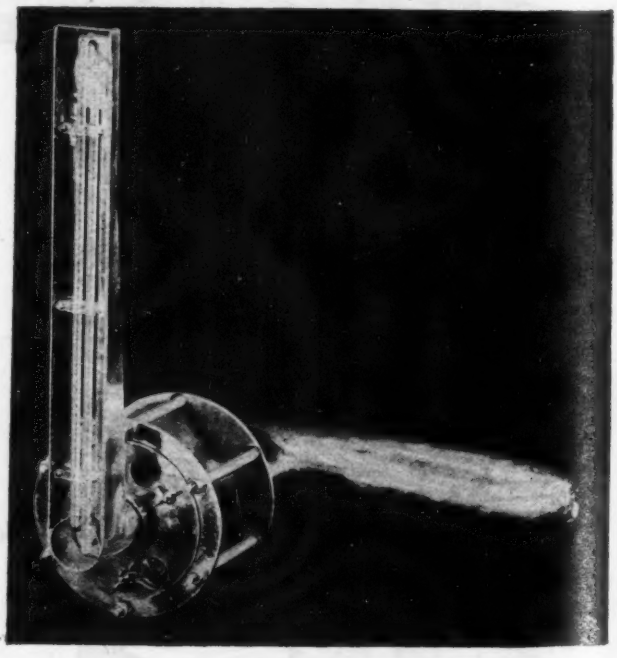


Ventilator—part of Psychrometer Equipment ML-313/AM(XO-2) —shown installed on airplane B-25G.

resulted in far more extensive weather briefing, for such missions, than has heretofore been possible.

A psychrometer is a simple instrument, but care is required in reading it. The most common type used for general surface observations consists of two identical mercurial thermometers mounted side by side on a single support. The bulb of one, the wet-bulb thermometer, is covered with a thin wet layer of muslin called a wick. The second thermometer is the dry-bulb thermometer.

Relative humidity is measured by determining the depression of the wet-bulb thermometer reading for any dry-bulb



Psychrometer and ventilator assembled—part of Psychrometer Equipment ML-313/AM(XO-2).

from sand . . .

SILASTIC

the new DOW CORNING SILICONE RUBBER

SILASTIC QUALIFIES EQUIPMENT UNDER GRADE 1, CLASS 1 SPECS.

Resistors coated with SILASTIC SC-75 operate successfully at 275°C. and take the plunge from 275°C. into ice water nine successive times. This seemingly impossible shock performance permits resistors coated with SILASTIC SC-75 to qualify under Grade 1, Class 1 Specifications.

"Newsworthy" is the development by Dow Corning of yet another—and perhaps greater—contribution to the new-day efficiency and resourcefulness of American industry. SILASTIC* is the name of the product and silicone rubber is the achievement.

SILASTIC covers a variety of elastic silicone products made by Dow Corning from sand, modified by chemicals drawn from brine, coal and oil.

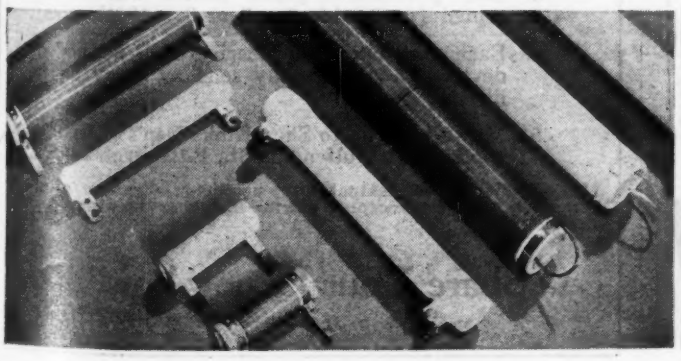
Being silicone rubber, SILASTIC exceeds in thermal stability the rubber we've known, whether natural or synthetic. SILASTIC retains complete flexibility—does not harden—in the temperature range—70°F. to 500°F. Its excellent dielectric properties—its arc, corona and oxidation resistance—assure durability of wire insulation under hot, wet service conditions.

For the immediate broad field of its usefulness, SILASTIC stocks are available for application by coating, extruding and molding.

DOW CORNING CORPORATION • MIDLAND, MICHIGAN

ADDRESS ALL INQUIRIES TO BOX 592

*TRADE-MARK DOW CORNING CORPORATION



Dow Corning

FIRST IN SILICONES

Why OHMITE RESISTORS Perform so Dependably

Resistance Wire Wound on Ceramic Core
Tin-Dipped Copper Terminal Lugs
Special Vitreous Enamel Holds Wire Rigidly in Place —Insulates and Protects the Winding
Convenient Mounting Brackets
Even Winding Prevents "Hot Spots" and Failures

Here you see a few of the important features that insure long life and trouble-free service in every Ohmite Resistor. In the lug type illustrated above, the resistance wire is both mechanically locked and brazed to copper terminal lugs to assure perfect electrical connection. Time-proved Ohmite vitreous enamel construction dissipates heat rapidly . . . withstands humidity.

Today, Ohmite Resistors are extensively used in the Armed Forces, Industry, Communications, Research. Made in a wide range of types and sizes in stock and special units for every need. Consult Ohmite engineers on your resistor problem.

Write on company letterhead for Industrial Catalog and Engineering Manual No. 40.

OHMITE MANUFACTURING COMPANY
4886 FLOURNOY STREET • CHICAGO 44, U. S. A.

Be Right with OHMITE
RHEOSTATS • RESISTORS • TAP SWITCHES

thermometer reading. As the moisture is evaporated from the wick on the wet-bulb thermometer, the temperature reading is depressed accordingly. If the relative humidity of the air is high, the amount of evaporation is small and the depression of the wet bulb is small. As the ambient temtemperature drops, which it does as we ascend into the upper air, the total possible amount of water vapor in the atmosphere becomes smaller and smaller; the range of wet-bulb depressions becomes smaller and smaller, and the possible accuracy of measurement tends to decrease even when the observer takes his readings most carefully. Careful calibration will determine errors inherent in the instrument itself and corrections required on account of the effects of airspeed, pressure, etc., have been carefully computed. When the appropriate corrections are applied to the observed readings of the airplane psychrometer, a corrected or "true depression" may be determined from which the relative humidity may be obtained.

Instrument-shop Officer's Invention Speeds Aircraft Armature Repair

CONSTRUCTED by Lt. Richard H. Herman of Schenectady, N. Y., at an Air Service Command depot in England, an ingenious device has reduced the time required for installation of armature quill shafts in combat plane generators from 15 minutes to as many seconds.

Soldier-technicians at Lt. Herman's depot, following the accepted method of removing the shaft, used to fit a jack against the ball-bearing shoulder of the armature and then proceed to yank at the shaft until it was free.

Salvaging a B-24 Liberator tail-turret hydraulic panel, an actuating cylinder from a P-47 Thunderbolt landing gear, and a P-51 Mustang landing gear selector valve, Lt. Herman built a machine that has eliminated all tugging and straining.

The armature is now placed into a fixture and an adapter fitted into the actuating cylinder rod. A flip of the selector

Cash for Shop Kinks

on instrument testing, repair, installing, etc.

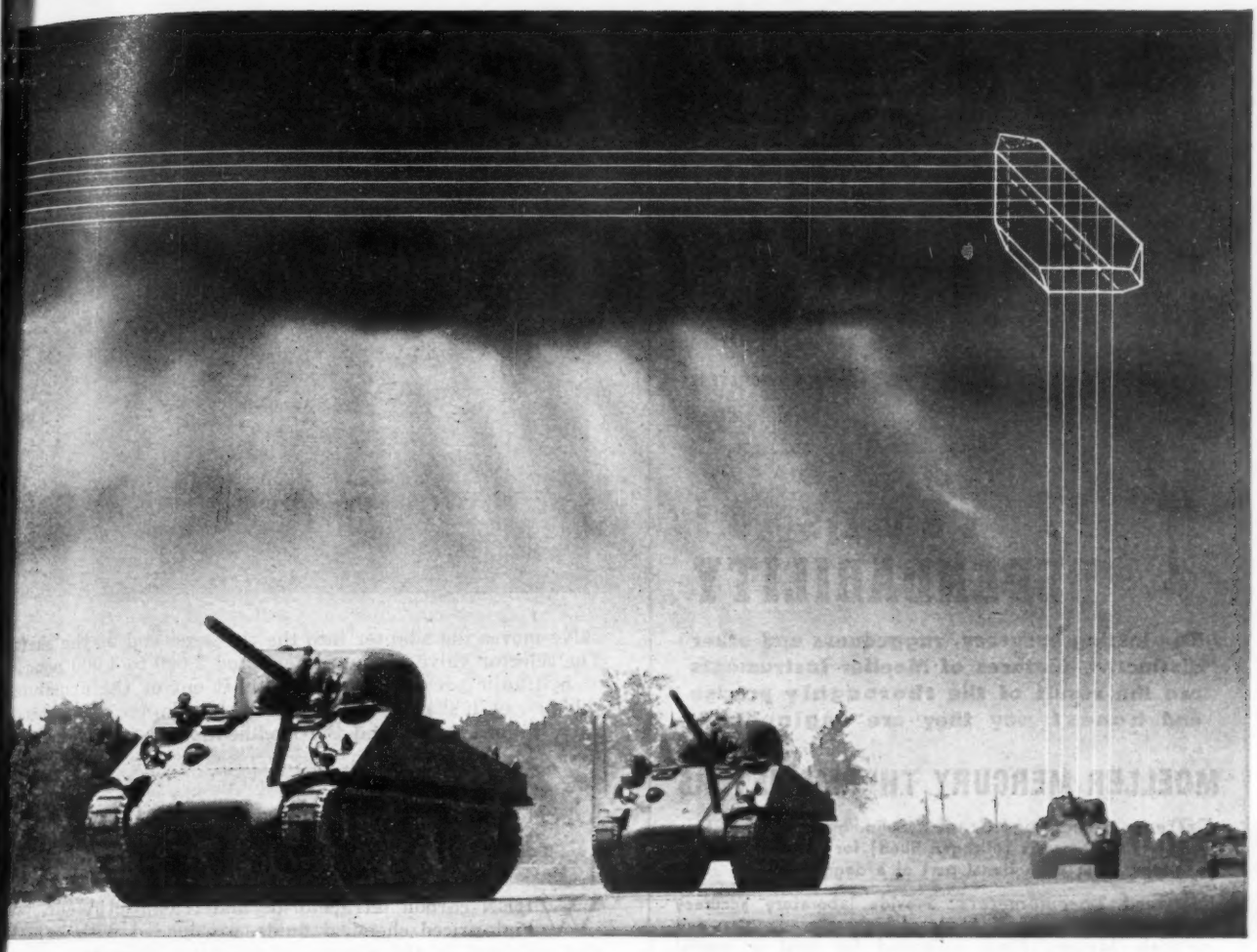
This is to remind our readers that *Instruments* pays $5 (or more*) for each shop kink or other time-saving and accuracy-promoting idea accepted for publication.

The following rules must be observed:

1. Type double-spaced on one side of paper. Author's name and address at top of first page (envelopes get lost!)
2. Diagrams must be in black ink (no blueprints). Lettering (if not made with aid of machine) may be soft-pencil, to be inked-in by *Instruments*.
3. Only professional-grade photos will be accepted (preferably 5 x 7 or 8 x 10 glossies).
4. Each contribution to describe ONE method or device. An author may send as many as he likes.
5. Mail all entries to Shop Kinks Dep't of *Instruments*, 1121 Wolfendale St., Pittsburgh 12, Pa.

*Five dollars is for textual entry accepted: a greater minimum is paid for accepted entries including drawings and photographs.

Share Your "Know-how"



War babies with glass eyes

These are the M4 tanks—30-ton war babies that see the enemy through the glass eyes of their fire control instruments and then shoot straight. Accurate optics for these and many other American tanks have been coming out of our plant in record quantities to meet urgent Army demands.

Keeping pace with the unusual speed of American tank production, while still maintaining the highest optical standards, is but one of the many jobs that is sharpening our skills for peace.

When the rush of war work is over, our compact group of precision lens specialists will be able to give you finer optics at lower prices. We are constantly finding better and faster ways to produce optical parts to meet the stiffest specifications.

That's why the Army and Navy keep coming to us with many of their most exacting optical problems. And that is why you will find the kind of service you need here when you are ready to manufacture peacetime optical or electronic products. For we specialize in working for others. We make nothing but optical components—no complete products of our own.

We will be able to give postwar manufacturers production with precision, quality with economy and original ideas based on sound scientific principles.

for precision OPTICS *come to*

AMERICAN LENS COMPANY, INC.

45 Lispenard Street, New York 13, N. Y.

LENSES • • • PRISMS • • • FLATS • • • REFLECTORS

MOELLER

PRECISION INSTRUMENTS

INDUSTRIAL THERMOMETERS
LABORATORY THERMOMETERS
RECORDING THERMOMETERS
THERMOSTATS
HYGROMETERS
HYDROMETERS
PSYCHROMETERS

MARINE SPECIALTIES, ETC., ETC.

77 Years of DEPENDABILITY

The lasting accuracy, ruggedness and other distinctive features of Moeller Instruments are the result of the thoroughly precise and honest way they are engineered.

MOELLER MERCURY THERMOMETERS

Extreme Precision Grade: Solid glass etched stem, mercury thermometers (nitrogen filled) for determining temperatures within a fractional part of a degree.

Standard Thermometers: Provide laboratory accuracy combined with sturdiness. Made of highest grade glass and materials. Mercury filled, calibrated for total or partial immersion. Types with "Moeller Glass Red Reading Column" afford optimum ease in reading.

Industrial Thermometers: High accuracy is easy to read under plant conditions because of "Moeller Glass Red Reading Column". Prevents eye-strain. V-shape case with glass front furnished in wide variety of forms such as: Straight Stem (see illustration above), Angle Form Types, Handle-Top Thermometers for use in food processing, galvanizing, etc., etc.

Separable Sockets, Extension Necks, etc., etc., available. Thermometer Test Wells — machined from solid bar stock.

DIAL and RECORDING THERMOMETERS

Made to strictest standards of precision, these mercury filled instruments are calibrated for ranges up to 1000°F. or equivalent. Square and round cases available. Metal and Phenolite cases.

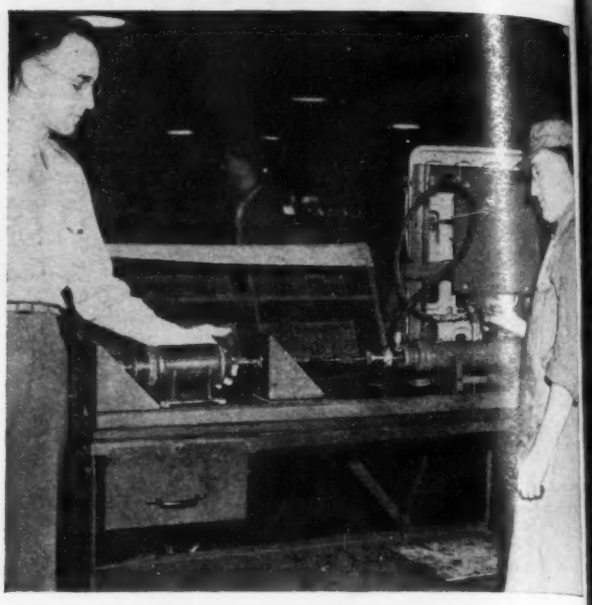
ARMY E NAVY

Write for catalog

MOELLER INSTRUMENT COMPANY — *SINCE 1867*

132nd STREET and 89th AVENUE
RICHMOND HILL NEW YORK

Sales Representatives in Principal Cities

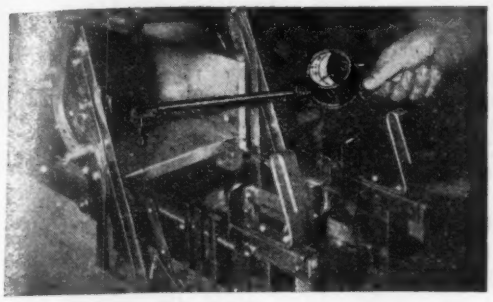


valve moves the adapter into the threaded end of the shaft. The selector valve is flipped back and 3,000 to 4,000 pounds of hydraulic pressure eases the shaft out of the armature. The new quill shaft is then put into the adapter, the selector valve flipped again, and the modification is completed.

Used Cleaning Fluids Purified by ASC Officer's Distilling Apparatus

WHEN carbon tetrachloride and trichlorethylene, two high-priced chemical fluids, are loaded with impurities collected in the process of washing aircraft engines, parts, etc., they lose practically all their cleansing properties. At an Air Service Command depot in England, soldier-technicians once disposed of these used liquids by pouring them down a drain pine and, at a dollar a gallon, many dollars were literally being poured away.

Attemps had been made to recover these fluids by using a system of filters. This separated the large particles from



Alnor PYROCON

...the contact pyrometer for quick accurate surface temperatures . . .

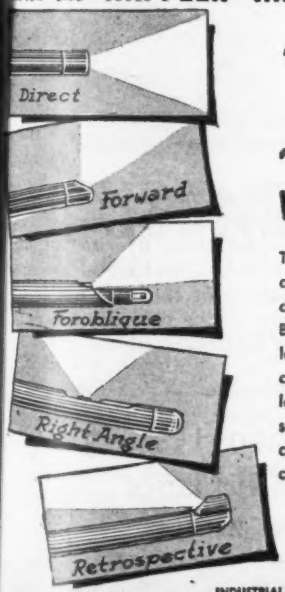
This convenient, all-purpose surface temperature pyrometer is ideally suited to a variety of industrial plant needs. Accurate temperature readings are obtained in a few seconds of plastic materials, liquids, oils, and similar materials, and of flat or curved, stationary or moving surfaces.

The Pyrocon shock-resisting movement is used with any one of eleven types of thermocouples, interchangeable without adjustment or re-calibration. Choice of rigid or flexible arms, or both, instantly interchangeable. Built in several standard ranges, 0-300 deg. F. to 0-1200 deg. F. Write for Bulletin 3511 giving complete description.

ILLINOIS TESTING LABORATORIES INC.
142 WEST HUBBARD STREET
CHICAGO 10, ILLINOIS

YOU CAN TURN A HOLE INSIDE OUT! OR SEE AROUND A CORNER!

with the **WAPPLER INDUSTRIAL TELESCOPE**



Inspection problems in the
EXAMINATION OF INTERNAL SURFACES
may be solved by means of

WAPPLER BORESCOPE

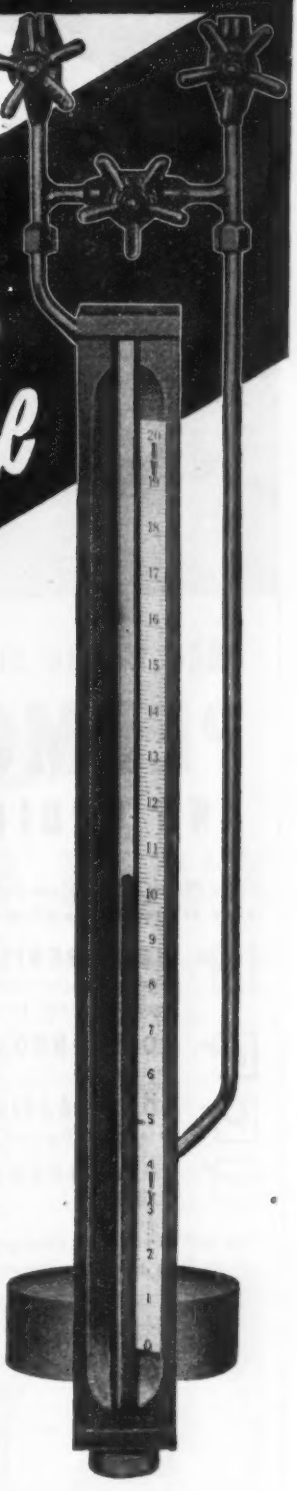
This is a telescopic instrument containing a lens system. The angles of vision for different type visual systems are shown. Borescopes range from .110" dia. x 3¾" long to .390" dia. x 72". Each instrument complete with conducting cord and spare lamp, and contains lighting circuit. Light source provided by batteries or direct connection to house current by means of current controller.

Write for Booklet

INDUSTRIAL DIVISION, DEPT. O

AMERICAN CYSTOSCOPE MAKERS, Inc.
1211 Lafayette Avenue New York 59, N. Y.

A MANOMETER ... YOU CAN High Pressure



This Meriam High Pressure Manometer (Model A-306) is tested at 4000 lbs. pressure. It is a direct reading, well type unit and fully meets the needs for an instrument to measure differential pressures for line pressures of 1200 to 1500 psi.

It consists of a machined alloy steel bar grooved for the gauge indicating liquid, held tightly against a heat treated glass bar by a rigid steel housing with an opening for readings.

This instrument is built in both wall and floor mounting models in ranges up to 40"; others upon special order. Send for Bulletin C.

THE MERIAM INSTRUMENT CO.
10958 MADISON AVE. • CLEVELAND 2, OHIO
WESTERN DIVISION: 1418 WILSON AVE., SAN MARINO 9, CALIF.
IN CANADA: PEACOCK BROS., LTD., MONTREAL

MERIAM Instruments
ESTABLISHED 1911

MANOMETERS, METERS AND GAUGES FOR THE ACCURATE MEASUREMENT OF PRESSURES, VACUUMS AND FLOWS OF LIQUIDS AND GASES

HERE IS THE DIFFERENCE BETWEEN

PERMOPIVOTS*

AND ORDINARY PIVOTS

Only PERMOPIVOTS are tipped with Permometal . . . a special alloy of precious metals produced by Permo Incorporated.

- **WEAR RESISTANT** . . . The Permometal tip gives precision instruments longer life and greater accuracy under actual operating conditions.
- **NON-CORROSIVE** . . . Permopivots cannot rust or corrode.
- **NON-ABRASIVE** . . . The satin-smooth tip eliminates abrading particles of wear.
- **NON-MAGNETIC** . . . K-monel shank material available.

The two unretouched photos reproduced below show why Permopivots keep precision instruments accurate longer.

PERMO INCORPORATED
MANUFACTURING METALLURGISTS
6423 RAVENSWOOD AVE.
CHICAGO 26, ILLINOIS
*T. M. Reg. U. S. Pat. Off.

WRITE TODAY FOR DESCRIPTIVE FOLDER
NO OBLIGATION

the liquid, but did not remove the oil, dirt, and grease which had dissolved and become part of the chemical fluid.

Since filtering failed to clean the carbon tet or the tri chlorethylene to any appreciable extent, production experts at the depot searched for a more satisfactory method.

It was at this point that a remark about "bootlegging" whiskey gave Lt. George W. Hofmann, of Cincinnati, the idea that the dirty cleaning fluids might be purified by distilling.

Constructing an experimental still with an electric hot plate, pyrex glass, aluminum tubing and rubber hosing, Lt. Hoffman conducted a series of tests with some used carbon tet. He found that after distillation the liquid was as pure as it was in its original state, and it could clean airplane parts just as effectively as the carbon tet from a freshly-opened can or drum. Hydrometer readings were the same as those listed in standard engineering handbooks.

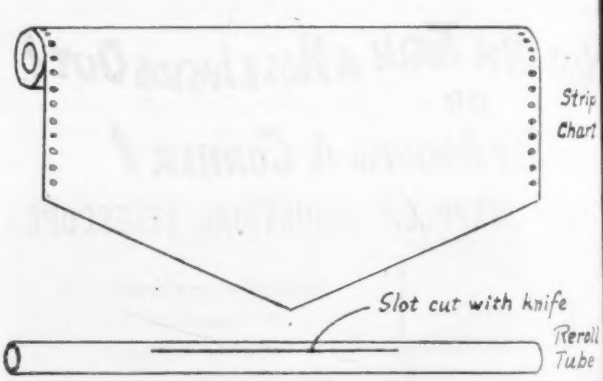
Bringing the results of his experiments to the attention of Capt. Harvey Smith of Bauxite, Arkansas, Chief of the Manufacture and Repair Department, Lt. Hofmann was granted permission to proceed with the building of a large still. Sludgy carbon tet is now "cooked" and reclaimed at the rate of almost 20 gallons an hour with only a 10 per cent loss due to evaporation.

SHOP KINKS

Fastening Recorder Chart to Reroll Tube

By ALBERT A. JACOBS, Brown Instrument Div., Minneapolis-Honeywell Regulator Co., Milwaukee, Wis.

DURING the war, instrument companies who formerly furnished clips for fastening a strip chart to the reroll tube of strip-chart recorders have had to dispense with this method and resort to substitutes. One method of doing this today is to use a gummed sticker.

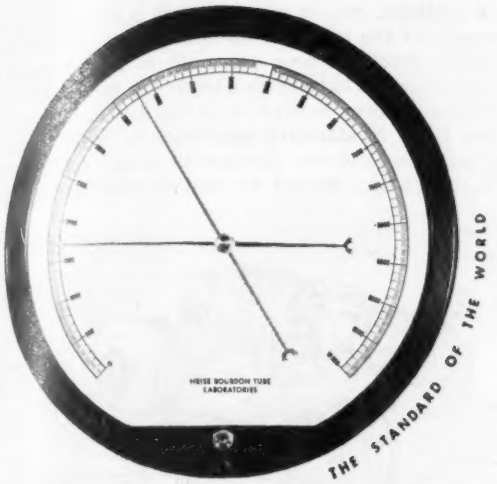


A simple and convenient way of accomplishing this, and one which readily allows for adjustment for perfect alignment—is to use a knife to cut a slot about five inches long in the reroll tube. The pointed end of the chart is inserted into this slot and two or three turns of the tube are made before inserting into the instrument. The tube can be easily slipped back or forth for proper alignment of the chart on the tube.

Portable Calibration Tester for Tachometers in Planes

By M. J. WIGGINS, AMMI-1c
"Somewhere in the Pacific-Asiatic Area"

IT is often necessary to check the calibration of aircraft tachometers in the ship, during periodic maintenance checks and while "trouble-shooting" on the line. Apparently, faulty tachometer readings are often caused by improper



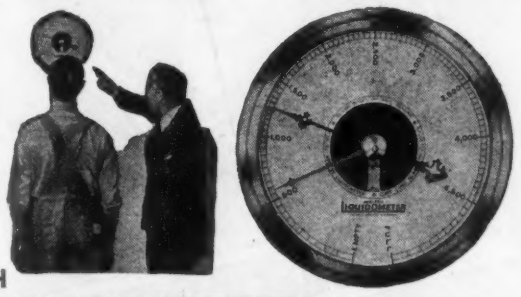
EVERY DAY we are shipping these precision pressure gauges to be used in place of dead weight testers. They are accurate, dependable and easy to read. Delivery—2 to 6 weeks.

RANGE FROM 0-25 lbs. to 0-10,000 lbs.

8½" Dial	126.50
12" Dial	144.00
16" Dial	176.00

HEISE BOURDON TUBE LABORATORIES
BROOK ROAD NEWTOWN, CONNECTICUT
IN COLLABORATION WITH THE A. H. EMERY COMPANY

ACCURATE LIQUID LEVEL INFORMATION AT A GLANCE, WHEN YOU WANT IT—



WITH
LIQUIDOMETER *Tank Gauges*
"THEY'RE ALWAYS DEPENDABLE"

100% automatic.
No pumps, valves, or auxiliary units needed to read them.
Models for either remote or direct readings.
Accuracy unaffected by specific gravity of tank liquid.
Approved by Underwriters' Laboratories for gauging hazardous liquids.

Write for complete details

THE LIQUIDOMETER CORP.
36-27 SKILLMAN AVE. LONG ISLAND CITY, N. Y.

You're Right!
YOU CAN'T GO WRONG

with
KESTER FLUX

• *Because Kester makes the* RIGHT *Flux for every kind of solder-bond.* Delicate, dip-soldered electrical connections, sweating operations, various types of seams, all demand a different and *correct* flux if they are to be permanent, and resist shock, vibration, bending, contraction, and expansion without failure!

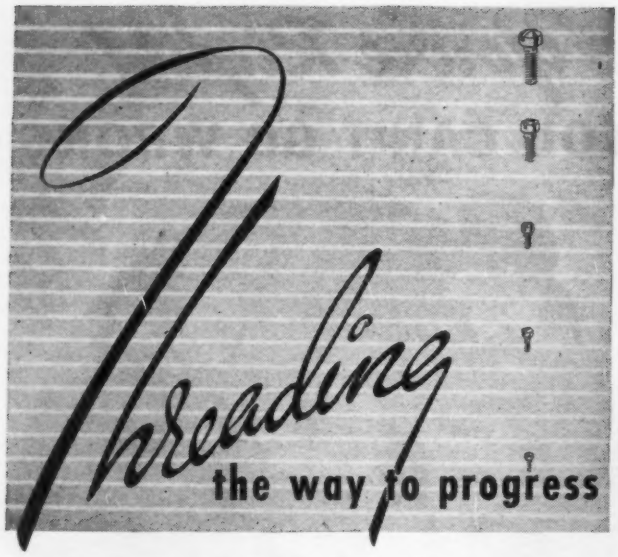
• *Because for 46 years Kester has pioneered in the field of solder and flux.* Kester engineers and technicians have laboratory-tested a vast range of fluxes for every possible requirement. You can't go wrong with Kester flux.

• *Because you can consult Kester engineers at any time for practical, experienced help.* They'll gladly suggest the right flux to protect your product. A letter today will bring expert Kester assistance—with no obligation.

★ BUY WAR BONDS ★

KESTER SOLDER COMPANY
4216 Wrightwood Avenue, Chicago 39, Ill.
Eastern Plant: Newark, N. J.
Canadian Plant: Brantford, Ont.

KESTER
Solder Fluxes
STANDARD FOR INDUSTRY



Screw Machine Products

- Progress — in the vast field of mechanics is to a great extent dependent upon fine screw machine products.
- Experienced Producers of screw machine products are essential to expedite efficient operation.

Your Source—
Waltham Screw Company because

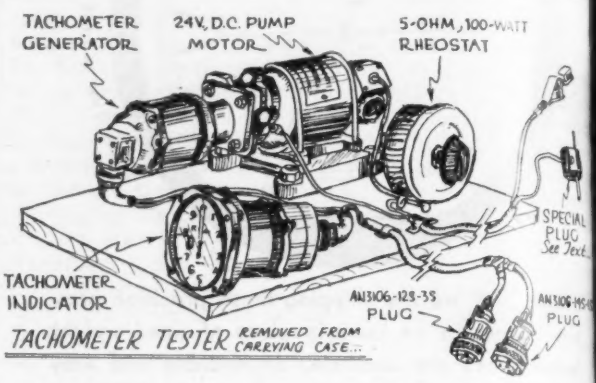
- Of sufficient equipment to produce in any quantity screws, tubes, shafts, inserts, nuts and other screw machine products in any thread to meet close tolerance requirements.
- Our experience gained in over half a century of development and production of screw machine products is available to you.

Send for our catalogue and call upon our Engineering Staff for solutions to your problems in screw machine products.

WALTHAM SCREW
COMPANY
71 Rumford Ave.
Waltham, Mass.

propeller settings, etc., in which case it is desirable to check the accuracy of the indicator to help isolate the trouble.

The tester described here was built to permit quick tests by using the plane's battery as a source of power. It will test both Army and Navy indicators of the synchronous generator-motor type. A standard generator is used to run the master indicator and the instrument under test. The generator is driven by a 24-volt d-c. motor whose speed is varied



TACHOMETER TESTER REMOVED FROM CARRYING CASE

with a rheostat. (The motor was obtained from a salvaged electric fuel pump.) A 5-ohm 100-watt rheostat provides speed control well within the range of the indicator. A short length of rubber tubing fitted over the square generator drive and pushed into the female spline drive on the motor provides a simple shock-absorbing coupling.

As shown in the drawings, two test plugs are used, as some indicators use a three-prong connector and the older type indicators have a two-prong connector. The "C" terminal on the three-prong plug is grounded to the shell, as the Navy instruments use a ground instead of "C." The motor leads have a battery clip on the negative wire, which is used

SEND FOR THIS
RESISTOR DATA

For the convenience of designers of products requiring resistors, Ward Leonard offers this new Resistor Handbook. It describes in detail the full line of wire-wound resistors giving complete information on mountings, enclosures, terminals and resistance values. Write for your copy today.

BUY MORE WAR BONDS

WARD LEONARD
Electric control devices since 1892.

WARD LEONARD ELECTRIC COMPANY
38 SOUTH ST., MOUNT VERNON, N. Y.

18 WAYS TO SAVE TIME & MONEY!

with the *Mead Industrial Burring Machine*

For WOOD - PLASTIC - METAL

New circular explains, illustrates 18 ways in which the Mead Industrial Burring Machine saves time and money—also contains special Grit Guide. Every industrial plant needs this "Jack-Of-All-Trades" machine. Your burring can be done in "free time"—install these machines by every machine tool which leaves burrs. Grinds, finishes both outside and inside cut-out openings. Immediate delivery in most cases. Write for the informative Money-Saving circular now.

MEAD SPECIALTIES COMPANY

1114 North Knox Ave. Dept. II-645, Chicago 41, Ill.

Now you can get

REED MICROMETERS

in sets—

SCHERR MICROMETER PARALLELS

Quick check on spindle end and anvil for parallelism and flatness. Occasional inspection with these optical parallels will instantly show degree of wear. Used by the makers in final inspection. Now available for users. Set of two, in case — **$30.00**

SIX MICROMETERS 1" TO 6" INCLUSIVE

These are the famous REED MICROMETERS that give you READINGS to 1/10,000" in 1", 2", and 3" sizes with accurate vernier, and 1/1000" in 4", 5" and 6". All have ratchet and spindle lock. Also available in metric reading, to 1/100 MM.

EXTREME LONG ACCURACY-LIFE of the micrometer screw, due to the Reed burnishing process of thread forming, which compresses the thread surface, insuring long wear, smooth operation, and constant lead accuracy within a fraction of 1/10,000" over the entire thread.

Checked any way you wish, these Reed Micrometers will be found rugged, and accurate to highest standards. Write us for full details, or order direct for quick delivery.

COMPLETE SET, $64.54

GEO. SCHERR CO., Inc. 199-A LAFAYETTE STREET NEW YORK 12, N. Y.

It doesn't matter to C.M.H. Stainless Steel Bellows!

You can't choose the temperatures of each bellows application, but you *can* use a product engineered to perform with equal efficiency . . . at both ends of the thermometer! We mean C.M.H. Bellows, made of 18-8 Austenitic *Stainless Steel,* with a working range of sub-zero to a scaling point of 1800° F.—wide enough to meet practically any heat or cold requirement.

Notice below the other advantages stainless steel and C.M.H. design bring you. Check and compare . . . and we think you'll want the full story of C.M.H. Stainless Steel Bellows!

Ask for Chicago Metal Hose Form SS B 2 on which to submit your bellows requirements. It will save you time . . . assure more accurate transmittal of essential data.

★ Corrosion resistant qualities of stainless steel enable wider application of C.M.H. BELLOWS.

★ Multiple ply construction gives even greater strength factors when needed.

★ Ferrous fittings, attached by Circular Seam Welding, assure permanent, leakproof joints.

★ Uni-metal assemblies avoid the costly troubles encountered where bi-metal types or solder joints are used.

★ Long lengths are standard production permitting economical use of C.M.H. Stainless Steel BELLOWS for many unusual types of applications.

★ Better delivery schedules are possible because C.M.H. BELLOWS are standard production products.

ARMY (E) NAVY Flexible Metal Hose for Every Industrial Use

CHICAGO METAL HOSE CORPORATION
MAYWOOD, ILLINOIS

Plants: Maywood and Elgin, Ill.

STATHAM

for

TEST ENGINEERS

Statham developments keep pace with your requirements. At last, Accelerometers and Pressure Transmitters which:

- Don't require amplifiers
- Need no balancing
- Operate from simple batteries direct to your oscillograph galvanometers
- Place no limitation on cable length
- Have high undistorted frequency response
- Possess temperature stability
- Are linear and accurate
- Maintain calibration permanently
- Are of durable construction
- AND, are small and light weight.

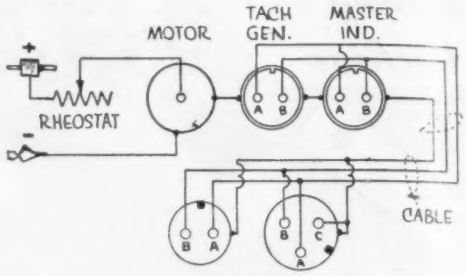
We make Accelerometers in any range and a complete line of Pressure Transmitters for aerodynamic and fluid pressures.

For further information write

STATHAM LABORATORIES INSTRUMENT MAKERS

8222 BEVERLY BOULEVARD • LOS ANGELES 36, CALIFORNIA

to clip onto a ground in the plane, and a special plug on the positive wire. This plug has two different size pins clamped in a block of insulating material. One of these pins is plugged into the cockpit power receptacle located on the plane's switch panel. There are two different size receptacles in use, one taking the large pin and the other the small pin.



TEST PLUGS

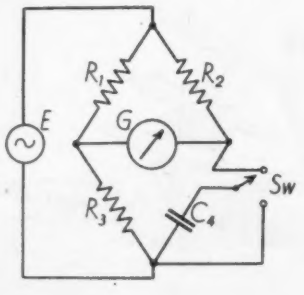
The tester is housed in a galvanized iron case, 5" × 7" × 12", fitted with a carrying handle. The case has a small hinged door on top so that the leads may be stored inside while not in use.

To test a tachometer in the plane, remove the plug from the indicator and connect the proper test plug, the motor leads being connected as described above. The plane's indicator is then checked at various points against the master indicator.

ELECTRIC GAGING METHODS

Continued from page 393

make their frequency sensitivity an advantage. Typical circuits are used for speed control, for analysis of waveforms, and for determination of frequencies. They are also sometimes used for determining the factor of merit or the Q of a resonant circuit.



$$N = R_1/R_2R_3C_4$$

FIG. 167

A sensitive, accurate method of speed control, based upon the early Maxwell bridge circuit, employs the circuit drawn as Fig. 167. This circuit comprises three resistance elements and one capacitive element, to which is connected a commutator or switching device which charges and discharges the capacitor at a rate exactly proportional to the speed of the rotating part. Since each charge and discharge of the capacitor transmits a discrete amount of electricity, the rate of energy transfer (that is to say, the current) is proportional to the number of times per second that these contacts operate. In effect, then, the capacitor with its switching device does the same work as would a resistor. The bridge circuit may be "balanced" according to the relation given in Fig. 167, and changes as small as one part in 10,000 are easily detected. In this equation, N represents the number of times per second the contactor operates.

The "balance" in this circuit is not the same sort of balance as that meant by the term in the foregoing discussion. In this circuit, the detecting instrument merely measures the amount of current flowing, its mechanical characteristics being such as to cause it to indicate an average value. "Balance" simply means that the *average* current flowing is zero; it is not true that no current flows at any time through the detector. This method was originally used

New ELECTRONIC RESISTANCE THERMOMETER

for Chemical Processing

THE BAILEY PYROTRON

As a resistance thermometer the Pyrotron indicates, records and controls temperatures between 100°F and 1200°F. It simultaneously records as many as four temperatures on its 12-inch chart, or may record and control as many as two temperatures.

An independent continuously connected measuring circuit serves each recording unit. These circuits are kept in continuous balance by sturdy motion-free electronic detectors which do away with the delicate parts and "step by step" action of galvanometer type instruments.

Indicating, recording and controlling instruments are furnished in rectangular casings as illustrated. Indicating and controlling instruments are furnished in 12-inch round type casings.

CHOICE OF THREE CONTROLS

Bailey Pyrotrons are furnished with the following types of Automatic Control:

1. **AIR OPERATED**—Uses standard Bailey Pilot Valves, air relays, control valves and control drives. Operates by compressed air at 35 lb. pressure.

2. **ELECTRONIC**—Uses standard electronic control panel operated from a control bridge in the Bailey Pyrotron.

3. **ELECTRIC CONTACTS**—Uses micro switches on slidewire unit or electronic relay operated from control bridge in the Bailey Pyrotron.

P-5

UNUSUAL FEATURES OF THE BAILEY PYROTRON

Suitable for severe service where vibration and shock exist.

Measuring circuit operates from instrument power supply eliminating need for standard cell and dry battery.

Sturdy electronic system maintains continuous balance.

Motor drive furnishes abundant power to operate recorders, controllers and alarm switches.

Two recording controllers may be housed in one casing.

Electronic units may be interchanged without disturbing instrument calibration.

For details, request Bulletin 230-A "Bailey Pyrotron Electronic Resistance Thermometer"
Bailey Meter Company, 1041 Ivanhoe Road, Cleveland 10, Ohio.
In Canada—Bailey Meter Company Limited, Montreal.

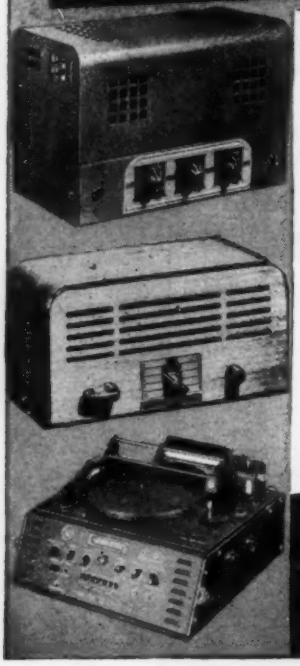
BAILEY METER COMPANY

1041 IVANHOE ROAD • • • CLEVELAND 10, OHIO

Controls for Processing

TEMPERATURE	FLOW
PRESSURE	LEVEL
% OXYGEN	DENSITY
% COMBUSTION	RATIO

AMPLIFIERS INTERCOMS RECORDERS



FOR EVERY PURPOSE

Concord's full line of Amplifiers range up to sizes covering 200,000 square feet indoors or 75,000 square feet outdoors. A complete line of speakers, microphones, and all essential equipment is also available.

Concord Intercom Units are carried in a variety of master and sub-station units permitting up to 100 stations.

Concord Recording Equipment—professional-type for microphone recording, radio recording, reproduction of transcriptions, public address system.

Write for special folders and literature which picture and describe the complete Concord line of Amplifiers, Intercoms and Recorders. Please address Dept. INS-65.

CONCORD
RADIO CORPORATION
Lafayette Radio Corporation
CHICAGO 7, ILL. 901 W. Jackson Blvd.
ATLANTA 3, GA. 265 Peachtree Street

For Testing **LIQUEFIED PETROLEUM GASES**

Pressure Hydrometer Jar

This instrument accurately measures the specific gravity of liquefied petroleum gases such as: butane, butadiene and propane, etc. It can be used on any liquid, which under atmospheric pressure would evaporate into a gaseous form.

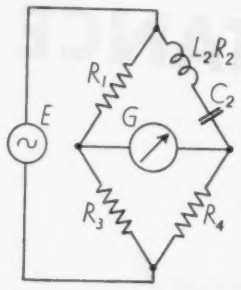
Constructed of Lucite tubing, it is made to withstand operating pressures of 200 lbs. per square inch.

The Refinery Supply Company can supply these instruments for testing and measuring liquefied petroleum gases — Corrosion-Test Bomb, Torsion Balance, Specific Gravity Bomb, Vapor Pressure Bomb, etc.

LABORATORY APPARATUS
SCIENTIFIC INSTRUMENTS
POWER PLANT EQUIPMENT

THE REFINERY SUPPLY CO.
Main Office and Plant
621 E. 4th St. • TULSA 3, OKLA. • Ph. 4-8144, L.D. 581
Branch Office:
1309 Capitol Ave. Houston 2, Texas Ph. Fairfax 5814

for the determination of capacitance in terms of resistance and rotary speed, and it employed only one of the two general balance conditions—the ballistic balance. No consideration is given to the resistance balance. The method is obsolete for its original use.



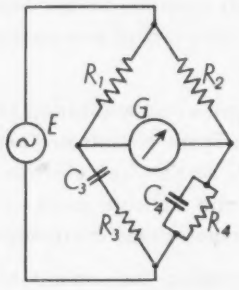
$$\frac{R_1}{R_2} = \frac{R_3}{R_4}$$

$$\omega L_2 = 1/\omega C_2$$

$$f = 1/2\omega\sqrt{L_2C_2}$$

FIG. 168

Bridge circuits employing resonant impedance arms make excellent devices for measuring frequency; the simple resonance bridge circuit of Fig. 168 can be used over a wide range of frequencies. It can be balanced at one frequency only, when the positive and the negative angles of the two reactive elements are equal and have an effective value of zero. At this frequency, only the ohmic resistance in that branch is effective, and the bridge can be balanced for resistance. The first two equations in Fig. 168 define this balance condition; the third may be used to compute the frequency at which balance is accomplished.



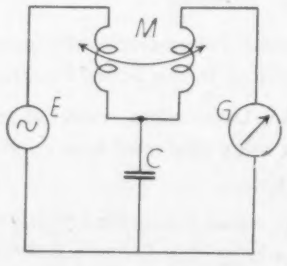
$$\frac{C_4}{C_3} = \frac{R_1}{R_2} - \frac{R_3}{R_4}$$

$$C_3C_4 = 1/\omega^2 R_3R_4$$

$$f = 1/2\pi RC \quad \begin{cases} R_3 = R_4 = R \\ C_3 = C_4 = C \\ R_1 = 2R_2 \end{cases}$$

FIG. 169

The Wien bridge circuit, containing only resistances and capacitances, is a suitable instrument for measuring capacitance values and can also be used for determining frequencies when the circuit components are known. It appears as in Fig. 169. The first two of the equations are used for determining capacitance values—or values of parallel resistance and capacitance, as in a leaky cable—while the others are used when the circuit is used in determination of frequencies. The method can be effectively applied to the analysis of the frequency components in a distorted wave-form; and it has also a wide application as the frequency-determining circuit in oscillator circuits.



$$\omega^2 = 1/MC = (2\pi f)^2$$

FIG. 170

A frequency-sensitive circuit which is perhaps the simplest of all such, and yet extremely efficient, is the Campbell frequency bridge circuit, employing mutual inductance. It is shown in Fig. 170; the balance equation is also given. This circuit is extremely sensitive to impurity in either mutual inductance or capacitance components, and also to the wave-form of the exciting energy. It can therefore be used to check the perfection of any of these, and provides a sensitive indication. It also is effectively

FEDERAL

Announces-

It Has Taken Over the Exclusive Sale of the

METRICATOR SYSTEM

AIR GAGE

INTERNAL

EXTERNAL

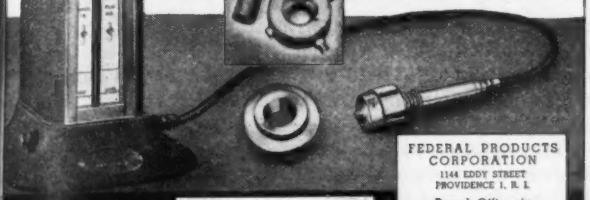
Manufactured by —
METRICAL LABORATORIES, INC.
ANN ARBOR, MICH. • EXCLUSIVELY FOR
FEDERAL PRODUCTS CORP.

This very successful system of gaging by air, recently introduced by Metrical Laboratories, as the "Metricator", embodies great magnification with exceptional accuracy, and in a very simple and efficient manner.

Practically any inside or outside dimension or depth, width, etc. can be gaged singly or simultaneously.

Pressure variations, moisture, and sludge in the airline do not affect the Gage.

Write for circulars describing this very efficient gaging system.



FEDERAL PRODUCTS CORPORATION
1144 EDDY STREET
PROVIDENCE 1, R. I.
Branch Offices in all principal Cities

FEDERAL

PRECISION MEASURING INSTRUMENTS

Engineers EFFICIENCY ANALYSIS *SERIES 3000* TEST SET

HAYS COMBUSTION SET

Portable
SIZE OF CASE 7⅛"x5"x15" HIGH
WEIGHT 9 LBS.

For accurate, quick combustion analysis. Combines single unit gas analyzer with a diaphragm type draft gage and flue gas thermometer. Completely enclosed in steel case with leather handle, weight 9 lbs. Of particular benefit to service and heating engineers and installers of oil and gas burners, stokers, furances, and boilers. Full details in Bulletin 43-362.

The HAYS CORPORATION
COMBUSTION INSTRUMENTS AND CONTROL
MICHIGAN CITY, INDIANA, U.S.A

ACCURATE INFORMATION NO GUESS WORK!

with STREETER-AMET

PRECISION EQUIPMENT

Accurate information is more necessary to industry than ever. The building of instruments to record weights, counts and other information . . . reliably and automatically . . . is the business of Streeter-Amet Company . . . has been since 1888. Since that date, this organization has developed and kept in readily accessible form a vast amount of technical "know how". This information is used not only to design, build and service weight recorders, traffic counters, tensile testers and related equipment . . . but it is available to firms concerned with the general problem of getting facts mechanically.

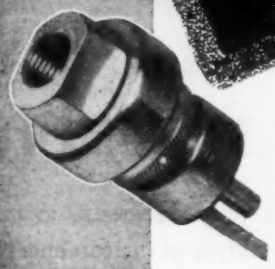
Besides, Streeter-Amet maintains a staff of practical, experienced field men, to give expert advice and service on all S-A equipment. Your inquiries are invited.

STREETER - AMET COMPANY
4097 N. Ravenswood Ave. • Chicago 13, Ill.
Automatic Weighers, Recorders, Scales and Services • Founded 1888

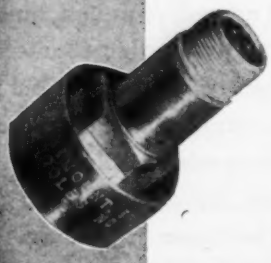
STREETER-AMET

DYNAMIC MEASUREMENTS
FOR *Every* INDUSTRY
WITH THESE *New* GAUGES

Trimount Series "A" and "N" Dynamic Pressure Gauges have wide application in aircraft and automotive fields, and in many other industries. They outdate, and are superior to, conventional instruments. Other dynamic gauges available for taking indicator cards on steam, gasoline, Diesel and gas engines, and on pumps and compressors.



The Trimount Series "A" Dynamic Pressure Gauge. The newest instrument for aircraft boundary layer and air foil pressure distribution studies in the laboratory or in test flight. Sequence readings can be made with banks of these instruments by means of a special Trimount switching arrangement, and studies impossible with conventional instruments are readily achieved. Features include: Frequency Response 0-500 C.P.S.: Sensitivity .4 of 1%: Linear Undistorted Pressure Response: Exclusive Integral Phase Balancer.



The Series "N" All-Purpose Differential Type Dynamic Pressure Gauge. For ground and flight test aircraft studies and in many fluid systems, such as fuel systems, intake manifold systems, and in many other locations. Gauge operation is simple. Extreme accuracy. Write today!

Electronics Division

TRIMOUNT
INSTRUMENT COMPANY 37 W. VAN BUREN CHICAGO 5, ILL.

used as a filter in analyzing waveforms; in that use it is notable for its sharpness of tuning. It is perhaps best used to detect small values of impurity in capacitors or inductometers. A number of modifications have been developed to permit its use with components possessing impurities.

To be continued

ELECTRIC MOTORS

Continued from page 388

Geophysical instruments use motors for driving the recording chart.

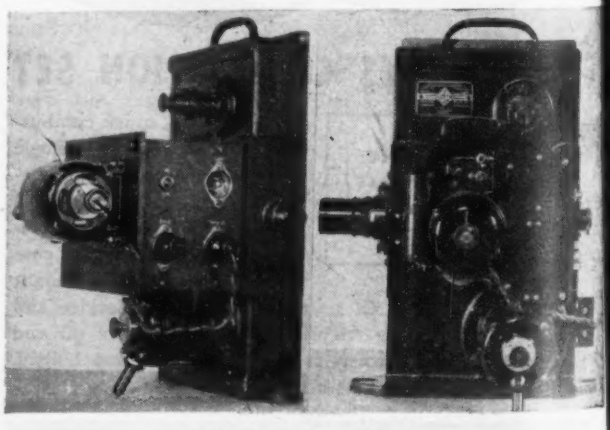
North American Philips, Inc., in their x-ray diffraction apparatus, use ten-watt Telechron units geared to 1 r.p.m. for rotating powder samples. On their crystal analysis and spectrometer units, 1/50-h-p. split-phase start induction motors are used for driving blowers for cooling of the x-ray tube. Rotatable-anode x-ray tubes use two-pole capacitor start-and-run motor parts, consisting of a 6" O.D. stator mounted external to the x-ray tube, which actually has only arm of the tube going through the stator. Within the sealed glass arm of the tube a copper anode mounted on ball bearings constitutes the rotor, which is operated at high speed. Another application is that of a small shaded-pole motor for driving the goniometer arm on an x-ray spectroscopic unit for scanning the diffraction pattern with automatic recording by a strip-chart recorder. Still another specialized application is that of a 1/20 to 1/10 h-p. induction motor driving a vacuum pump on hermetically-sealed test units for testing quartz crystals.

Two specialized applications of the General Radio Co. illustrated herewith, are powered by high-speed series-wound ball-bearing motors, one of which uses an integral speed reducer. One of these units is their Oscillograph Recorder, and the other a High-speed Continuous-film Camera. This is an application in which the high-speed camera uses an electric governor, which is not mounted on the motor shaft but rather on the film sprocket shaft.

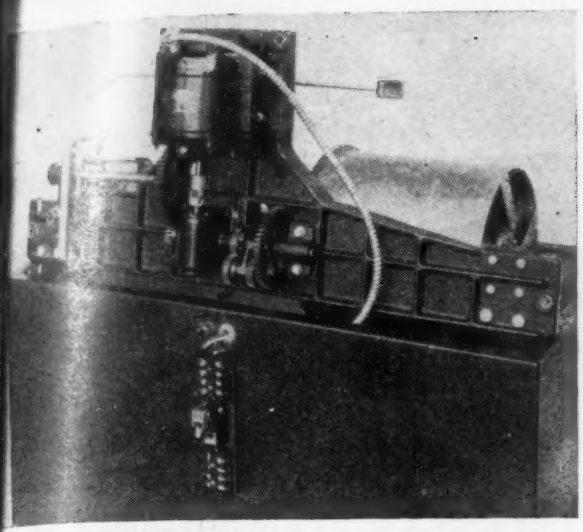
Other applications for motors range from electric-governor-controlled series universal motors for driving revolving mirrors or string oscillographs, operating special mechanisms in meterological instruments, to the standard ⅛-h-p. induction motor driving the Cutler-Hammer Calorimeter. Here, in the scientific instrument field, the number of motor operated devices is again veritably legion.

4. Automotive Test Instruments

From a volume standpoint, automotive test instruments before the war were manufactured by a number of people and represented a very considerable market for small motors. Some of these motors were electric-governor-controlled series universal units rated in the neighborhood of 1/15-h-p.



(LEFT) General Radio Co. Type 651-AG continuous film camera for taking high-speed stroboscopic pictures at rates up to 1500 frames per second. Also used for high-speed photography with cathode-ray tubes. (RIGHT) General Radio Co. Type 651-AE oscillograph recorder. Two motors are used. The upper motor drives the film sprocket. The lower motor drives the lower reel, which winds up the film. These series motors would be rated approximately 1/15 horsepower.



Cutler-Hammer recording calorimeter tank unit. Metering unit swung up on pivots, showing standard 1/8th horsepower induction motor drive.

quipped with speed reducers, for operating distributor testg units. Other motors were used for operating centrifugal lowers on CO_2 combustion indicators.

Aeronautical Equipment

Aircraft instruments currently in quantity demand use any types of special motors, which have been discussed in e analysis of motors. The various types of applications inolved include gyro-horizons, attitude gyros, directional yros, Gyrosyn compass, gyro-pilots, automatic controls of l types, computing gunsights, bombsights, hydraulic pump otors, ammunition boosters, bomb hoists, tab controls, cowl aps, recorder and elevator controls, and many others.

PROCESS CONTROL APPARATUS

In this category we are likely to find apparatus that uses ot only small motors, but makes use of, or controls, much arger motors as part of a process control system. In this eld we find apparatus such as manufactured by Askania Regulator Co. for automatic control for large steam generatng units, temperature and combustion control in steel mills, nd turbine and engine controls. Askania equipment utilizes oth electrical and hydraulic actuating members. Some of he equipment uses large positioning Selsyns, which in turn ontrol the operation, through a mechanical servo system, of ydraulic units.

The Askania hydraulic units require motors of substantial ize to drive hydraulic pumps. Other motors are required or operation of blowers and dampers. Rather interestingly, he deflection beam tube developed by Askania is the elecrical equivalent of the hydraulic jet pipe which constitutes n essential element of this company's control apparatus.

In the same field of process control apparatus are many f the temperature controllers, recorders and pressure and low instruments made by a variety of manufacturers, such s Brown, Tagliabue, Bailey, Foxboro, Bristol and many thers, where the instruments depend primarily for operaion on electric motors of small size, but which in turn often ontrol much larger motors on various positioning mechanisms, valve operators, dampers, blowers, pumps and many ther related items of a process control system.

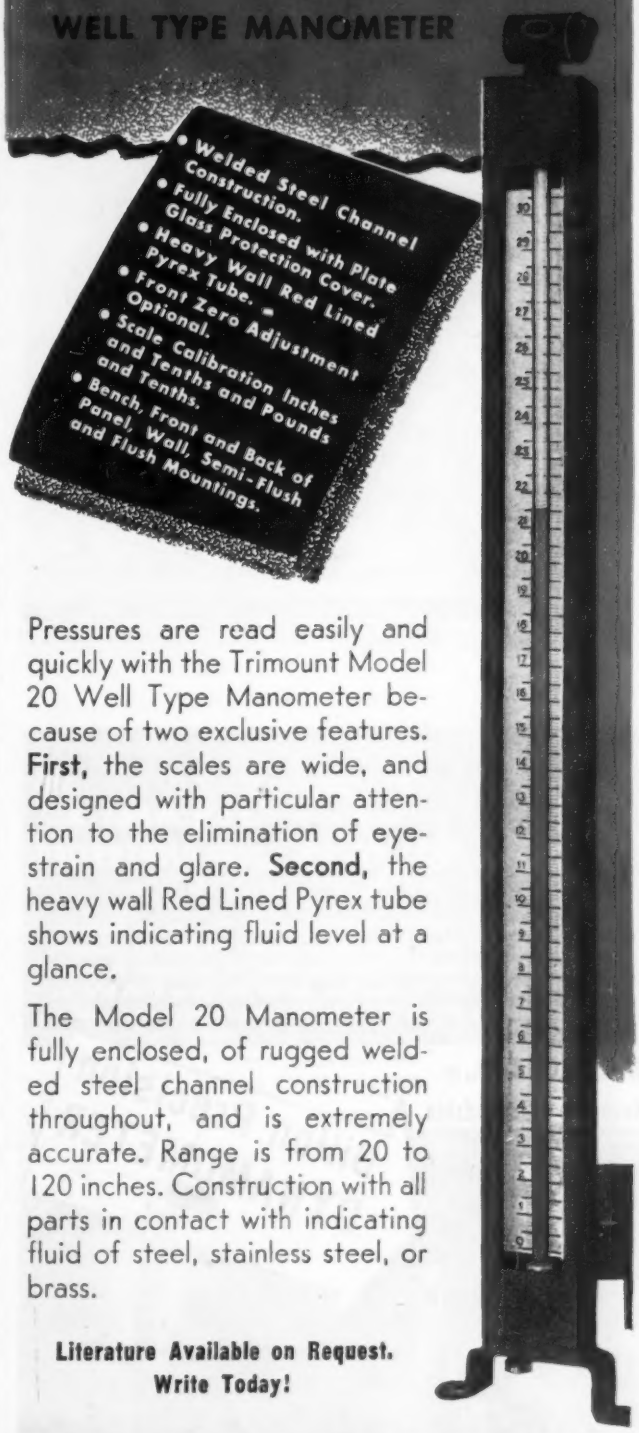
Thus the field of process control apparatus is related to nd interdependent on the successful performance of larger ower units which are automatically controlled.

An ingenious instrument having application to the field of process control is the electrical telemetering system developed by the Bristol Co. under their trade-name Metameter, which uses a measured ratio of time-on to time-off in cyclically-repeated equal time intervals to transmit a measured value to a distant point for indication and control purposes. The Bristol Metameters themselves use small hysteresis synchronous motors for driving the operating cam in the transmitter and also the recording chart in the receiver

READ PRESSURES *Easily*

AND *Quickly* WITH THIS

WELL TYPE MANOMETER


• Welded Steel Channel Construction.
• Fully Enclosed with Plate Glass Protection Cover.
• Heavy Wall Red Lined Pyrex Tube.
• Front Zero Adjustment Optional.
• Scale Calibration Inches and Tenths and Pounds and Tenths.
• Bench, Front and Back of Panel, Wall, Semi-Flush and Flush Mountings.

Pressures are read easily and quickly with the Trimount Model 20 Well Type Manometer because of two exclusive features. **First,** the scales are wide, and designed with particular attention to the elimination of eyestrain and glare. **Second,** the heavy wall Red Lined Pyrex tube shows indicating fluid level at a glance.

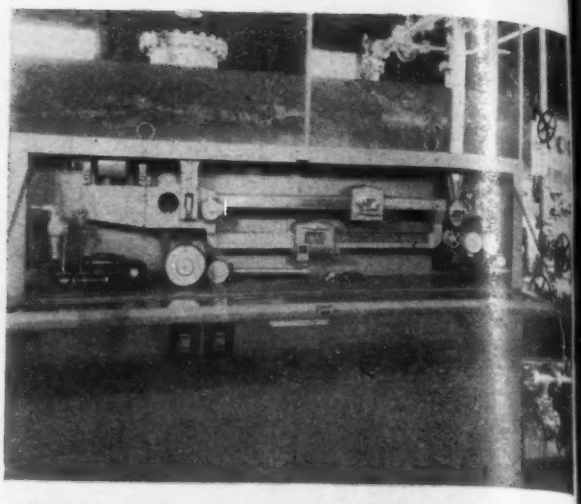
The Model 20 Manometer is fully enclosed, of rugged welded steel channel construction throughout, and is extremely accurate. Range is from 20 to 120 inches. Construction with all parts in contact with indicating fluid of steel, stainless steel, or brass.

Literature Available on Request. Write Today!

TRIMOUNT

INSTRUMENT COMPANY 37 W. VAN BUREN CHICAGO 5, ILL.

More or Less
CAN MAKE A
BIG DIFFERENCE
Let an accurate Dillon Dynamometer handle the various weighing problems in your shop. Ideal for quick spot checking at inventory time or when production materials must be weighed. Measures only 8¼" x6¼" x3" : 9 capacities: 0-500 lbs. up to 0-20,000 lbs. — all reasonably priced. Write for technically illustrated catalog.
W.C. DILLON & CO., INC.
5415 WEST HARRISON ST.
CHICAGO 44, ILL. U. S. A.
Accurate • Dependable
Dillon Precision
DYNAMOMETER



Proportioneers, Inc., continuous automatic tetraethyl lead blender, with motor-driven balancing of beam scale providing for dosage adjustment and automatic control. Bodine frame N12 gear reducer motor rated approximately 1/50th horsepower drives the balancing weight.

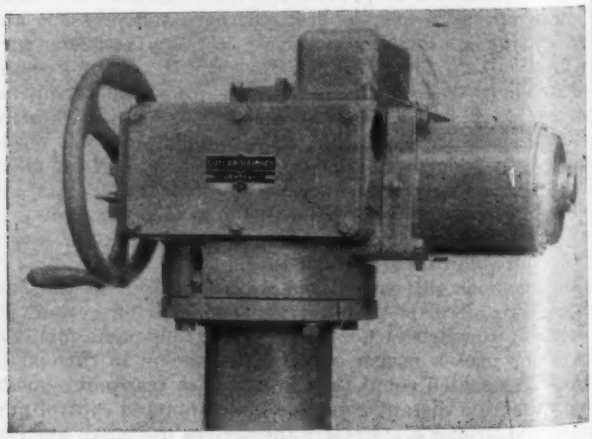
unit. As in other systems, the controlled apparatus in turn frequently involves the use of larger motors. While these larger motors are usually bought by the manufacturers of the particular apparatus, such as a valve or pump, their presence in a process plant as part of a control system involves interdependence on each other of each element in such a system, and a mutual stake by the manufacturer of each part of such a system in the overall success of the system as a whole.

Proportioning equipment is another very important class of motor-operated process control apparatus which uses a variety of motors, both as to type and size. A typical illustration is the equipment of Proportioneers, Inc., illustrative of some of this proportioning equipment is the view of the scale beam used on an automatic tetraethyl lead blender. This uses a Bodine Type N12R frame gear reducer motor.

Similar motors are used on other equipment for controlling the stroking rate of multiple proportioning pumps of the hydraulically-operated type.

Motor operated valves are a necessary element in process control, and are made by a large number of manufacturers in a variety of sizes and for a multitude of purposes. Typical of the larger units is the accompanying illustration of a Cutler-Hammer motor operated valve control. Units of this type generally use ball bearing polyphase induction motors in sizes from ½ horsepower up to 10 horsepower or more.

Also in the field of process control are such other equipments as motor-operated rheostats, principally used for controlling generator and motor fields, but fulfilling a variety of other applications where variable control of medium power sources is required. Typical of this class of appara-



Cutler-Hammer Manufacturing Co.'s floor-mounted motor-operated valve control, using ball-bearing flange-mounted polyphase induction motors.

long stem

KETTLE and TANK THERMOMETERS

for varnish, oils, milk, jams, food, etc.

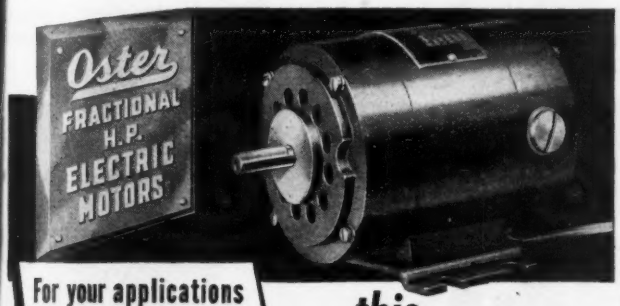
These red-reading mercury thermometers have metal cases and flat glass fronts. Temperature ranges from 30° up to 750° F, or equivalent centigrade. They are permanently accurate and will withstand all normal hazards of industrial service.

STEM LENGTHS
12"
24"
30"
36"
48"
60"
72"

Other items in the H-B line include thermostats, relays, thermo-regulators, hydrometers and many other types of thermometers. H-B Instrument Company, 2525 No. Broad St., Philadelphia 32, Pa.

THERMOMETERS • THERMOSTATS • RELAYS
THERMO-REGULATORS • HYDROMETERS

DOUBLE H B DIAMOND



For your applications requiring light weight, compact design, and maximum performance

...this

OSTER MOTOR

has the features that "fill the bill"

HOUSING—Die cast, open or totally enclosed.

FINISH — Black, baked enamel.

BEARINGS — Single, shielded ball bearings. Bearing housing fitted with steel inserts.

BRUSHES — Furnished with metal graphite or electro graphite brushes of ample size to assure unusually long brush life. Phosphor bronze or beryllium copper brush springs.

WINDINGS — Available for operation on 12, 24 or 115 volts, in shunt, series and split series types.

MOUNTING — Available for either base or flange mounting.

MODIFICATIONS — Motors can be furnished with special shaft extensions, finishes, leads, etc. Motors can also be furnished for operation in high ambient temperatures and high altitudes.

All ratings and data are approximate.

M-18B

John Oster Mfg. Co.
DEPARTMENT N-18 • RACINE, WISCONSIN

A NAME WORTH *Remembering!*

We are still fighting a tough foe in the Pacific. But, let's hope the day won't be too far off when we can force the Jap to his knees, too.

And, at the same time, we face new problems on the home front—the gradual conversion to civilian production—the return of millions of fighting men to peace-time jobs.

So, with one eye on the Jap, let's keep the other on postwar plans, new product developments, new contacts. Let's build and plan for full peace-time production and prosperity.

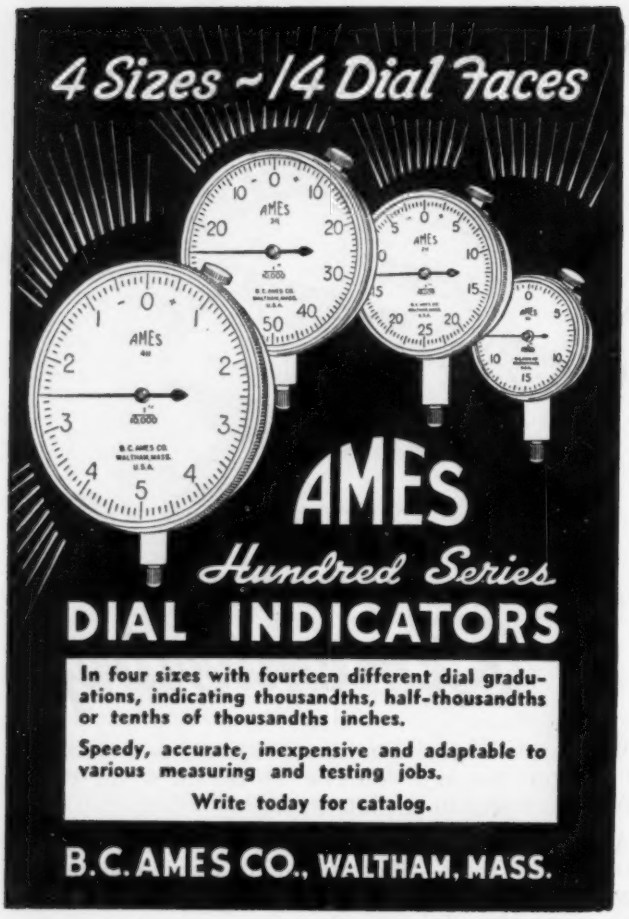
SOMCO is ready—ready to convert at a moment's notice—ready to assist you. SOMCO products can play an important part in your own postwar plans. Keep posted on SOMCO product developments—born of years of applied research.

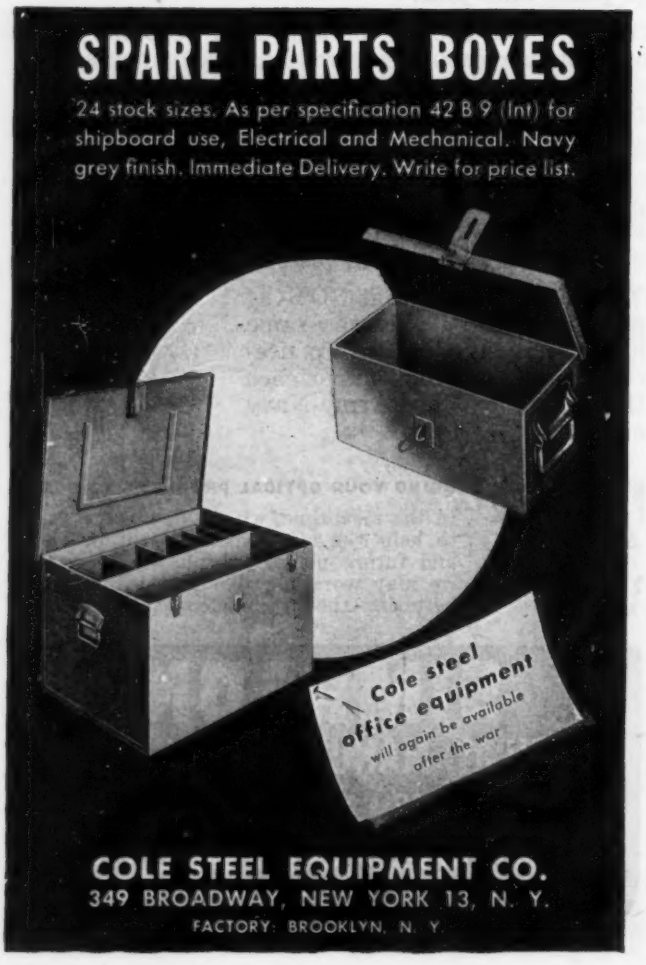
You may be sure that SOMCO products will embody the same high quality, craftsmanship, precision, and know-how experience that won for us five Army-Navy citations.

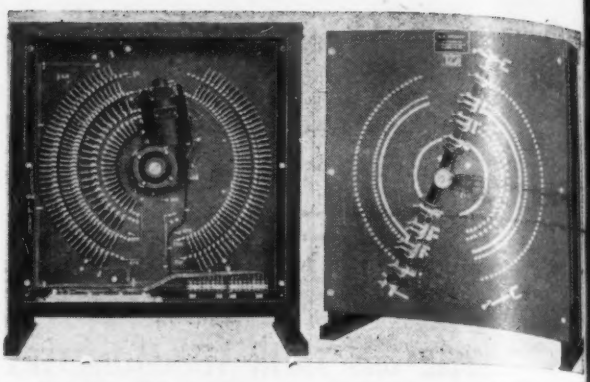
BRING YOUR OPTICAL PROBLEMS TO SOMCO

In the meantime, we are as always, ready to help you solve your present problems and future plans. Consult us freely that we may work together in the interest of bettering the days to come.

SIMPSON
OPTICAL MANUFACTURING CO.
3200 WEST CARROLL AVENUE • CHICAGO 24, ILL.
★
PROJECTION LENSES • CAMERA LENSES • PRISMS
OPTICAL FLATS • SOUND OPTICAL SYSTEMS AND
LENS COATING FOR LOW REFLECTION


4 Sizes ~ 14 Dial Faces
AMES
Hundred Series
DIAL INDICATORS
In four sizes with fourteen different dial graduations, indicating thousandths, half-thousandths or tenths of thousandths inches.
Speedy, accurate, inexpensive and adaptable to various measuring and testing jobs.
Write today for catalog.
B.C. AMES CO., WALTHAM, MASS.


SPARE PARTS BOXES
24 stock sizes. As per specification 42 B 9 (Int) for shipboard use, Electrical and Mechanical. Navy grey finish. Immediate Delivery. Write for price list.
Cole steel office equipment will again be available after the war
COLE STEEL EQUIPMENT CO.
349 BROADWAY, NEW YORK 13, N. Y.
FACTORY: BROOKLYN, N. Y.



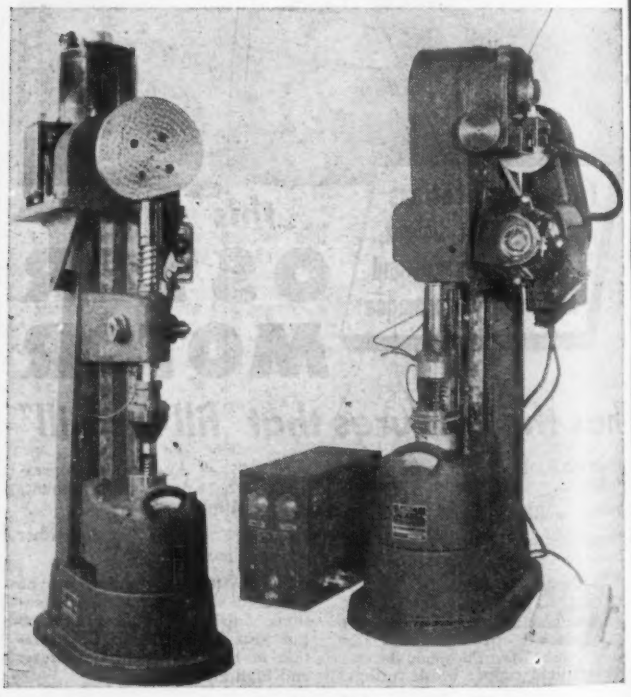
Clark Controller Co. motor-operated field rheostat. (LEFT) rear view showing application of vertically-mounted totally-enclosed ball-bearing gear reducer unit. (RIGHT) Front view of same unit.

tus are the illustrations of the Clark Controller Company's motor-operated field rheostats.

Physical testing apparatus is another large class of equipment, much of which uses electric motors of various types for its operation. Tensile testing machines, tortion testing machines, centrifuges, hydraulic pressure testing equipment, are just a few of the many classes of apparatus which depend on motors, some of them of very considerable size. Typical of this type of equipment are the accompanying illustrations of spring testers manufactured by Link Engineering Co. This manufacturer advises that, while their needs are generally taken care of by standard motors, one feature they would appreciate would be variable speed in small a-c. motors.

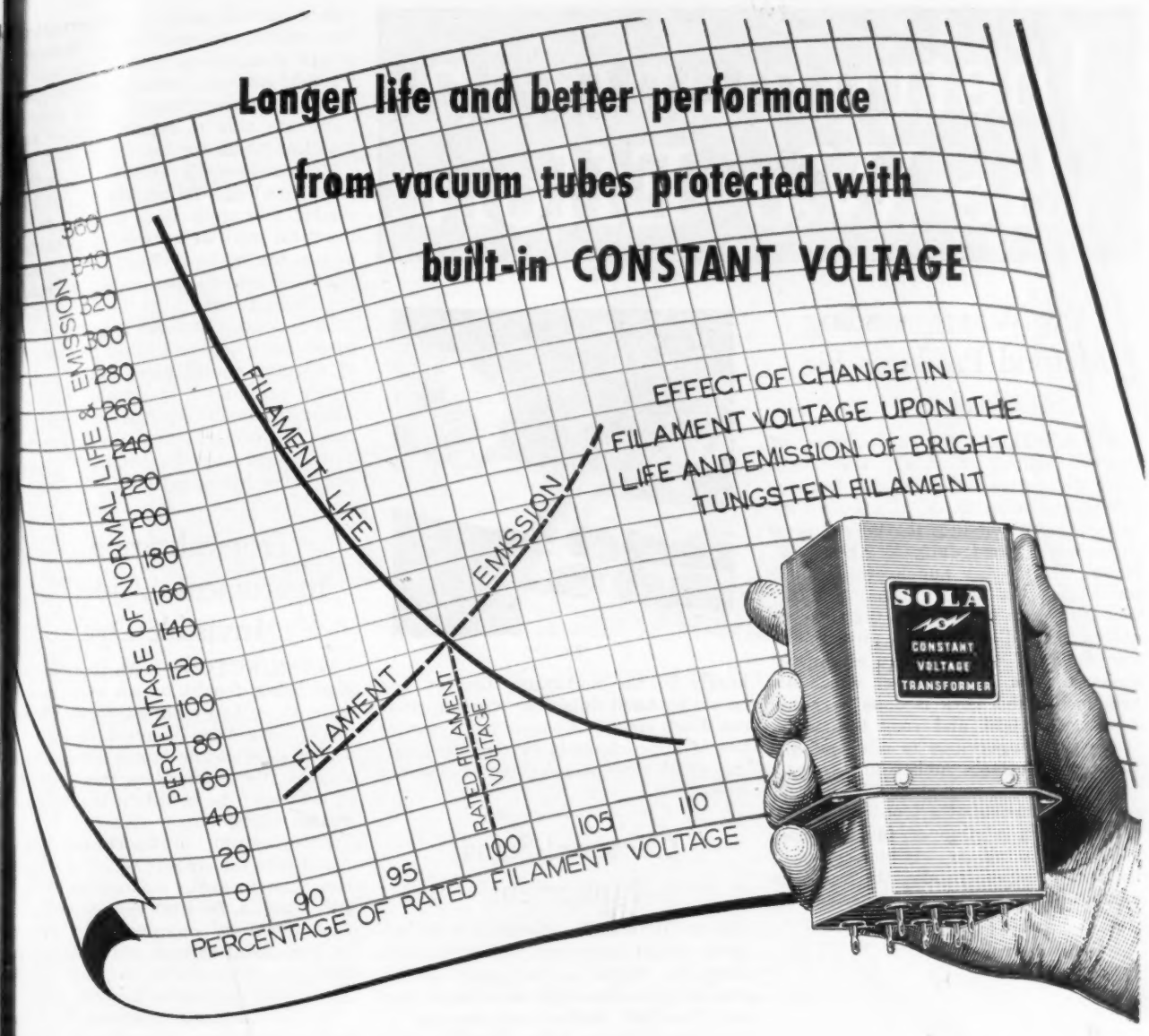
CONCLUSION

As was stated in the introduction, the range of applications in the field of instruments and control apparatus is so broad that we could never hope to make it complete. The above illustrations are not by any means the limit either as to types or fields of apparatus that could be discussed, but we hope that they may serve to indicate the great variety and large aggregate volume of electric motors and motive power devices that are used.



Lin't Engineering Co. spring testers. (LEFT) 1,000-lb. capacity tester with pushbutton control arranged to compress springs to a preset height and then stop. The motor is a ½ horsepower three-phase induction motor with built-in magnetic brake. (RIGHT) Continuous-running tester, 250-lb. capacity, with cam drive to slow up the stroke over the point where the load is read. Motor is a ¼th horsepower split-phase start induction geared head motor.

Longer life and better performance from vacuum tubes protected with built-in CONSTANT VOLTAGE



A 5% over-voltage will reduce the life of a tungsten filament by 50%.

A 5% under-voltage will cut filament emission by 33%.

Commercial line voltages today may vary as much as ± 20%.

With a SOLA Constant Voltage Transformer as a built-in component of your equipment, these line voltage variations can be ignored. No need to depend upon operator adjustments. No need to worry about operator forgetfulness. You can depend on it—the right voltage is *always* there.

Vacuum tubes protected by SOLA Constant Voltage Filament Transformers require no starting resistors or high reactance transformers. Filaments are automatically and positively protected against damaging inrush currents. Tube life is noticeably prolonged.

SOLA Constant Voltage Transformers require no supervision, or manual adjustments by the operator. They eliminate the need for voltmeters. They are fully automatic, have no moving parts, tubes or networks, and are self-protecting against short circuit.

Standard units are available in capacities from 10 VA to 15 KVA either for the operation of equipment now in use or as built-in units. Where special problems confront the designer, consultation with SOLA engineers may provide a positive and economical solution.

To Manufacturers:
Built-in voltage control guarantees the voltage called for on your label. Consult our engineers on details of design specifications.
Ask for Bulletin GCV-102

SOLA Constant Voltage Transformers

Transformers for: Constant Voltage • Cold Cathode Lighting • Mercury Lamps • Series Lighting • Fluorescent Lighting • X-Ray Equipment • Luminous Tube Signs Oil Burner Ignition • Radio • Power • Controls • Signal Systems • Door Bells • and Chimes • etc. **SOLA ELECTRIC CO., 2525 Clybourn Ave., Chicago 14, Ill.**

Instruments in the War Effort

New Watch-winding Method Produces Big Savings

BELLEVILLE, N. J. — Strips of tough, resilient Compar, the vinyl resin derivative developed by Resistoflex Corp., Belleville, N. J., are used ingeniously for winding the hundreds of time-pieces tested daily by the U. S. Naval Observatory and by the Hamilton Watch Co. This unusual application reduces to two seconds the time required to wind each watch, protects the fine finish of the case and eliminates finger fatigue and callouses which develop when the work is done by hand. Light of weight and easy to handle, Compar is impervious to oils and solvents, and outlasts rubber 30 to one.

The device in use at the Naval Observatory consists of a foot-long paddle covered with a strip of fabric-backed Compar. Placing the winding crown of the watch on the paddle, the watch is wound by a single quick motion, as

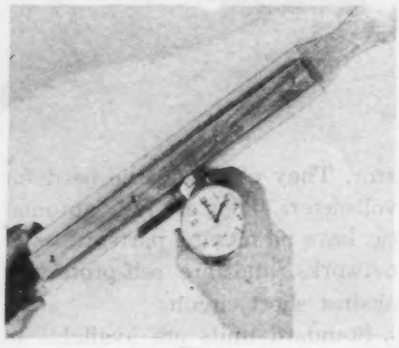


Fig. 1

shown in Fig. 1. A similar strip of Compar is fastened to the numerous work benches in the Observatory where fairly large timepieces or instruments —many of which have stiff stem winds —are wound during the adjustment period.

In the production of high-grade watches at Hamilton Watch Co., it is necessary to keep an accurate record of the performance of each watch. Some are tested for accuracy in as many as six different positions, which entails 15 or more windings. To speed up the operation, strips of Compar 4″ by 10″ are fastened securely to work benches. With the watch held firmly in one hand the crown is run along the bench, as shown in Fig. 2, until the watch is wound

Fig. 2

nearly to the maximum. One or two twists by hand finish the winding process. Each strip of Compar has a service life of approximately two months, during which time over 50,000 watches are wound.

Captured Signal Equipment

WASHINGTON.—German and Japanese signal equipment which falls into American hands is hastening the defeat of our enemies in more ways than one. Carefully studied and analyzed by the United States Army Signal Corps, it plays an important role in the eventual destruction of the hostile armies that developed it.

Four vital uses are made of this captured equipment:

1. It gives direct aid in developing counter tactics to make enemy signal devices less useful and effective.

2. Any valuable ideas or devices worked out by the enemy are incorporated in American equipment.

3. American signalmen are trained in the use of enemy radios and other communications items.

4. Intelligence officers are enabled to assess the economic state of an enemy country by checking for inferior materials found in the equipment.

These advantages are not left to chance or to the varying technical capacity of different men. Not only captured signal equipment but all possible information relating to it is forwarded to the Camp Coles Captured Equipment Section of the Signal Corps Ground Signal Agency at Bradley Beach (N. J.), and to the branches at Camp Evans and Fort Monmouth, where it is minutely studied, analyzed and correlated. The results are made known to appropriate channels so that signalmen in the field are well versed in the specialties and peculiarities of enemy devices. They are able to repair, operate and maintain them for their own uses.

Teams specially trained to further this knowledge follow the troops into combat and apply their training to the practical work of testing and repairing and to the no less vital task of teaching other men to operate the equipment that is captured.

In general it has been found that captured radio sets and other instruments of German manufacture reveal considerable originality of design. Those of Japanese manufacture are curious mixtures of German, American and British designs and are often of a type which our Army would consider obsolete.

Tropicalization of Instruments Aided by Invisible Dye

WASHINGTON—With the Japanese War being fought on an ever greater scale, U. S. Army Signal Corps Laboratories have been spurred to new research in scientific tropicalization, and a recent development is the use of an invisible dye to facilitate inspection of treated equipment.

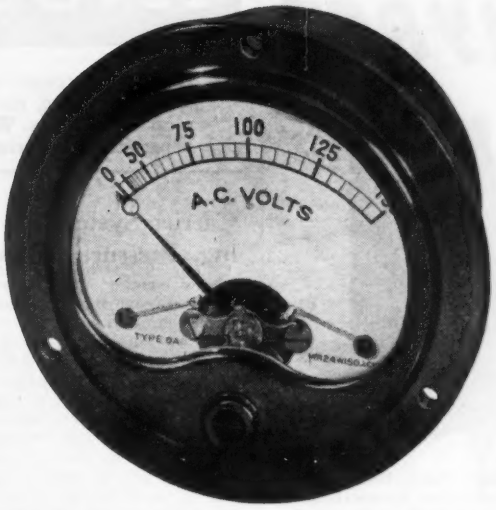
This invisible or fluorescent dye is mixed with the lacquer which is sprayed over instruments, instrument components, radios, field telephones and other communication equipment to prevent the inroads of fungus and moisture, its chemical composition varying according to the particular lacquer used.

All the lacquers, whatever their content, are colorless, or nearly so, in order that the numbers and the identification marks on the various instruments, may be plainly read through them. The result is that it is not easy, by ordinary vision, to check on the thoroughness and evenness of the spraying.

To aid in this, a special lamp, strong in its emission of ultraviolet rays and equipped also with a deep purple filter, comes to the aid of those responsible for inspection. This lamp, directed upon the equipment, picks up the ultraviolet dye in the lacquer (though it is invisible to the eye) and shows clearly any imperfections in the spraying.

A simple field expedient which can be used in the field to discover weak spots in the spraying is to try writing upon lacquered equipment with an ordinary pencil. Wherever the pencil glides as if on glass the spraying has been adequately done. If it "starts to write" it has found a weak spot. Often the tropicalization of communication equipment can then be completed in the field. But the need for improvisation in battle areas arises less frequently now that new methods aid in inspection of equipment tropicalized at home.

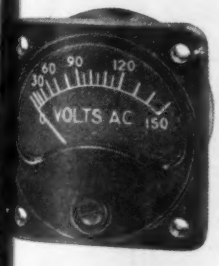
1.5" Commercial Type OD d-c Milliammeter



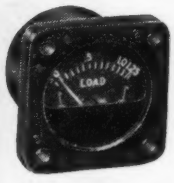
2.5" Commercial Type DA a-c Voltmeter. 400 cycle

New R-S Instruments—

built to Rigid Specifications



2.5" Aircraft Type AN a-c Voltmeter. 400 cycle



1.5" Aircraft Type G-1 d-c Ammeter. Immersion Proof

In the air, where life itself is at stake, no failure of instruments because of construction or assembly can be tolerated. Roller-Smith aircraft instruments have always been built to the most rigid specifications. We are naturally proud of the fact that the Army Air Forces, Air Technical Service Command has assigned us an "Approved" Quality Control Rating covering instruments delivered in accordance with contract specifications.

Commercial types of these two aircraft miniature panel instruments are built in conformity with the same exacting requirements.

ROLLER SMITH

Sales Representatives In all Principal Cities

ROLLER-SMITH BETHLEHEM, PENNA.

Canadian Plant: ROLLER-SMITH MARSLAND, LTD., Kitchener, Ontario

STANDARD AND PRECISION ELECTRICAL INSTRUMENTS • AIRCRAFT INSTRUMENTS • SWITCHGEAR • AIR AND OIL CIRCUIT BREAKERS • ROTARY SWITCHES • RELAYS • PRECISION BALANCES

YOU CATCH trouble before it catches you —if you own a HYPOT

HYPOT High Voltage Insulation Breakdown Tester. Model 406 illustrated. 3 KVA 0-3000 volt secondary, 115 volt 60 cycle primary, 500 milliampere secondary circuit. Complete with burning ground circuits and rubber-tired wheels. 20′ high voltage test leads, 50′ input leads, 50′ ground leads.

THE INSTRUMENT THAT WILL FOREWARN YOU OF PROBABLE ELECTRICAL FAILURE.

With a HYPOT you can quickly locate insulation faults that would burn out in service.

HYPOT

has ample capacity for all testing. Quick, easy control from 0 to maximum voltage. 5 models available for all services.

EASILY PORTABLE UNIT

HYPOT Model 406 is equipped with rubber tired wheels for easy moving. Complete safety to operator and equipment.
Prompt delivery.

WRITE FOR COMPLETE FACTS AND DATA—TODAY!

ASSOCIATED RESEARCH Incorporated

233 South Green St. Chicago 7, Ill.

The Month's NEW INSTRUMENTS

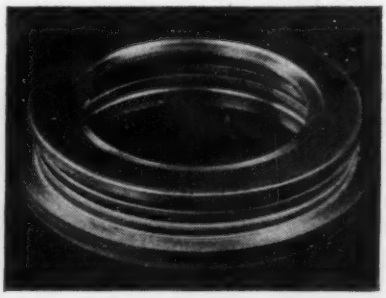
In this department we report each month new devices for measurement, inspection, testing, metering and automatic control—in the form of concise technical descriptions. When writing to manufacturers directly, please mention this department. Or write to Information Section, Instruments Publishing Company.

Carrier System for Electric Gaging, Pressure Measurement, etc.

New carrier system is for use with dynamic pressure gages and other primary instruments to measure static and dynamic pressures, vibration, acceleration, torque and strain, clearance between moving parts, angular position, etc. System is designed for aircraft test work involving boundary layer studies and other specialized applications; internal combustion induction system pressures; and for general industrial use. System is available in two series, one making use of modulated carrier wave principle; other employing discriminator circuit. Frequency ranges are as high as 10,000 c.p.s. Power supply and oscillator are small and lightweight and can be furnished in any number of channels required. Each amplifier channel is supplied with an individual oscillator. This permits setting individual channels at different frequencies; also allows for greater overall accuracy: should a pick-up or network element fail, remaining channels are unaffected. Any one of a number of gages is used as a primary element, and a cathode-ray oscillograph or recording oscillograph, or other suitable recording or indicating equipment can be used with new carrier system. Indicator cards on engines, pumps or compressors can be made when system is used with recording equipment. Other applications include blower rim and supercharger pressures, full-system pressures, air-scoop pressures, impact loads on hulls, and landing-gear shock loads. System is said to have many advantages over conventional measuring equipment, among them virtual absence of temperature effect—*Electronics Div., Trimount Instrument Co., 37 W. Van Buren St., Chicago 5, Illinois.*

Rotating Seal

New "Spring-life Gyro-Seal" is a rotating seal of an entirely new type. No auxiliary springs are required in the application of "Gyro-Seals" because the inherent spring rate of "Spring-life" bellows is, in most cases, sufficient to maintain the required pressure on the sealing surfaces. The bellows can be made of all types of metals to suit the conditions of each application. "Gyro-Seals" will operate on both external and internal pressure, and have been built to withstand 5,000 lbs./in.^{2} pressure in a range from slower than 1 r.p.m. to faster than 4,000 r.p.m. Lapped finishes of the sealing members can be furnished to meet specifications wherein surface flatness is required to be true to one light-wave—*Cook Electric Co., 2700 Southport Ave., Chicago 14, Illinois.*

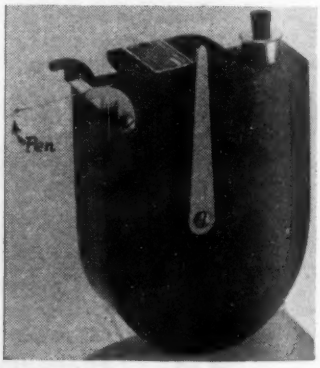


Redesigned Platinum Thermocouple Assembly

New improvements in platinum thermocouple assemblies used with two-hole silica blocks for glass tank crowns will result, it is said, in longer service life for the protecting tube assembly and will facilitate removal of the thermocouple assembly for periodic inspection. Major improvement consists in replacing with heat-resisting stainless steel the secondary protecting tube previously made of steel. This change, it is said, will reduce oxidation to a minimum, eliminate freezing of the tube, and permit its removal for inspection. This change will become effective on orders after July 1.—*Brown Instrument Co., 4482 Wayne Ave., Philadelphia 44, Penna.*

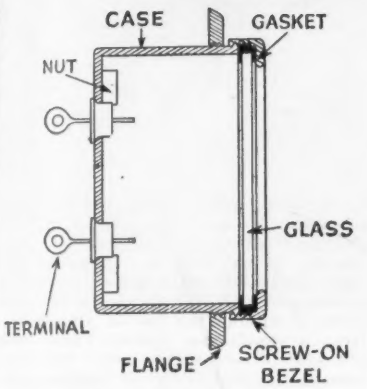
Ink-type Recording Mechanism with Oscillograph Speed

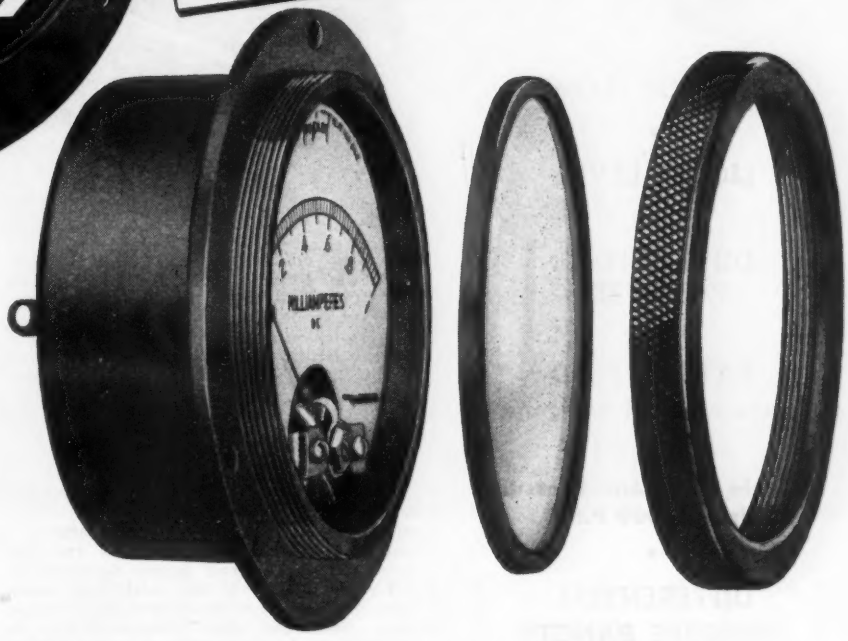
New "Brush Recording Galvanometer" makes direct ink-on-paper chart recording of wider frequency range and greater sensitivity than heretofore attainable. It em-



bodies a low-mass 3″ long tapered-tube recording pen, actuated by a permanent-magnet pen-motor utilizing newly developed material and techniques. Pyrex tipped pen faithfully records directly in ink on a moving paper chart, pressures, vibrations, strains, currents and voltages of frequencies from d.c. to 120 c.p.s. It has no overshoot up to 70 c.p.s. at a maximum swing amplitude of 20 mm. each side of center line. [That is to say, it can record without distortion a "70-cycle square wave" of 1 9/16″ amplitude.] Frequency response is flat to 70 c.p.s., accurate to 120 c.p.s. Pen can be conveniently centered on chart, as well as raised from chart. Impedance of pen-motor is 1500 ohms. Minimum sensitivity is 1.1 mm. per volt, 1.6 mm. per ma., 21 volts full-scale. Overall dimensions (5″ high × 4″ deep × 1⅝″ thick) facilitate close spacing

INTRODUCING THE NEW TRIPLETT LINE OF HERMETICALLY SEALED INSTRUMENTS





ALL THE FEATURES of STANDARD INSTRUMENTS RETAINED

Withstands submersion tests at 30 feet

A screw-on bezel provides uniform pressure for hermetically sealing the glass to the case. The gasket is pressed into every crevice around the edge of the glass and the top of the case, where the permanent seal is made.

Tempered glass window and ceramic sealed terminals are used.

The knurled screw type bezel permits servicing when necessary and resealing without replacing a single part or the use of special tools or equipment.

Complete dehydration of the interior is readily accomplished by recognized temperature difference method (the bezel loosely attached for the escape of all moisture, after which the bezel is tightened to make the permanent seal). Interior is completely dry at slightly above atmospheric pressure.

These instruments comply with thermal shock, pressure and vibration tests. They also are resistant to corrosion. Instruments conform to S.C. No. 71-3159 and A.W.S. C-39.2-1944 specifications.

Furnished in 1½", 2½" and 3½" metal cases with 1/16" thick walls, in standard ranges. D.C. moving coil, A.C. moving iron and thermocouple types.

Write for circular

Precision first ...to last

Triplett

STANDARDS ARE SET BY TRIPLETT

ELECTRICAL INSTRUMENT CO. BLUFFTON, OHIO

MODEL 163
INDICATOR
Differential Pressure Type

RATE OF FLOW

•

LIQUID LEVEL

•

DIFFERENTIAL PRESSURES

•

RATE OF FEED
of hydraulically driven equipment

•

Suitable for Static Pressures Up to 3,000 P.S.I.

•

DIFFERENTIAL PRESSURE RANGES
From 0-50 inches W.C. To 0-30 P.S.I.

•

RUPTURE-PROOF BELLOWS UNIT

An exclusive feature. Sensitive and accurate under high operating pressures. Withstands extreme over-ranging.

•

Write for descriptive bulletin No. 11C2.

Attention Mfrs' Representatives. Your Territory May Be Open

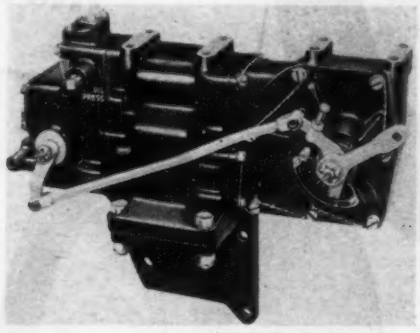
•

BARTON INSTRUMENT CO.
2306 East 38th Street
LOS ANGELES 11 CALIFORNIA

of multiple units: minimum is on 1¾" centers. Four No. 10-24 tapped holes are located in rear face for convenient mounting. A large ink-well minimizes frequency of refilling. New recorder weighs 4 lbs., is available as shown; or with 3-speed paper drive (2" wide chart) one or two channels; or with single-speed paper drive (12" wide chart) four to six channels. Purchased on AA-4 or better, 60 to 90 days.—*The Brush Development Company, 3405 Perkins Ave., Cleveland 14, Ohio.*

Automatic Boost Control

New "Eclipse Automatic Boost Controls" are designed for application to various single-stage single-speed and single-stage two-speed supercharged aviation engines to



protect the engine from detonation or overstress and to reduce pilot fatigue. [Owing to military restrictions, design and engineering data on Eclipse Automatic Boost Controls are available only to manufacturers approved by the U. S. Government.]—*Eclipse-Pioneer Division, Bendix Aviation Corp., Teterboro, N. J.*

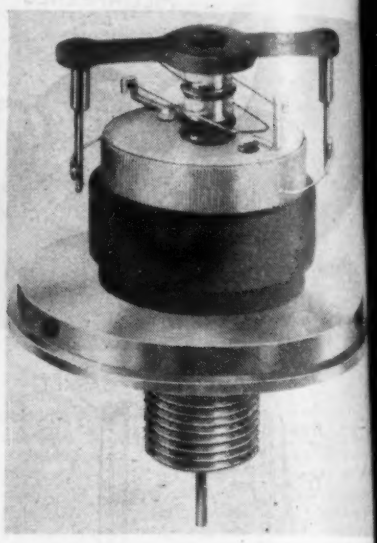
1%-accuracy Resistors

New "Series 82 and 83 Riteohm Precision Resistors" are added to maker's line. These new units may be mounted by means of a through-bolt. "Riteohm 82" has two lug terminals at one end firmly fastened by screws. "Riteohm 83" has radial wire leads. Both new units are pie-wound to 1% accuracy. Enameled alloy resistance wire is non-inductively pie-wound on a non-hygroscopic ceramic bobbin which has a hole

through the center for a No. 6 screw. After being wound, units are vacuum-impregnated with a special varnish which provides additional insulation and thoroughly protects winding against humidity. New resistors can be supplied with a varnish coating containing a fungicidal agent for use in tropics. "Riteohm 82" is available in three sizes: 1 1/16" diameter by 1 1/8" long, 1 7/16" long or 1 3/4" long for the 2-, 4- and 6-pie units respectively. Minimum resistance is 0.1 ohm for all units and maximum is 400,000 ohms for the 2-pie unit, 750,000 ohms for the 4-pie, and 1 megohm for the 6-pie unit. "Riteohm 83" is available in three sizes: ½" diameter by 7/16" long, 5/8" long or 1" long. First two units are 2-pie; third is a 4-pie unit. Minimum resistance is 10 ohms for all units and maximum is 200,000 ohms for the small 2-pie unit, 400,000 ohms [illegible] the large 2-pie, and 800,000 ohms for [illegible] 4-pie unit. A few common applications [illegible] new resistors are voltmeter multipliers, laboratory equipment, radio and electric test sets, attenuation pads, etc. — *Ohmite Mfg. Co., 4835 Flournoy St., Chicago Illinois.*

High-sensitivity Resistors

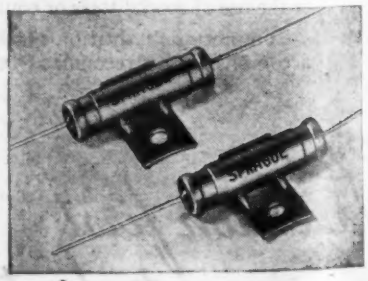
New "Autoflight" high-sensitivity resistors for instruments and recording systems are the first of their kind built in the United States. Their overall dimensions are 1[illegible]



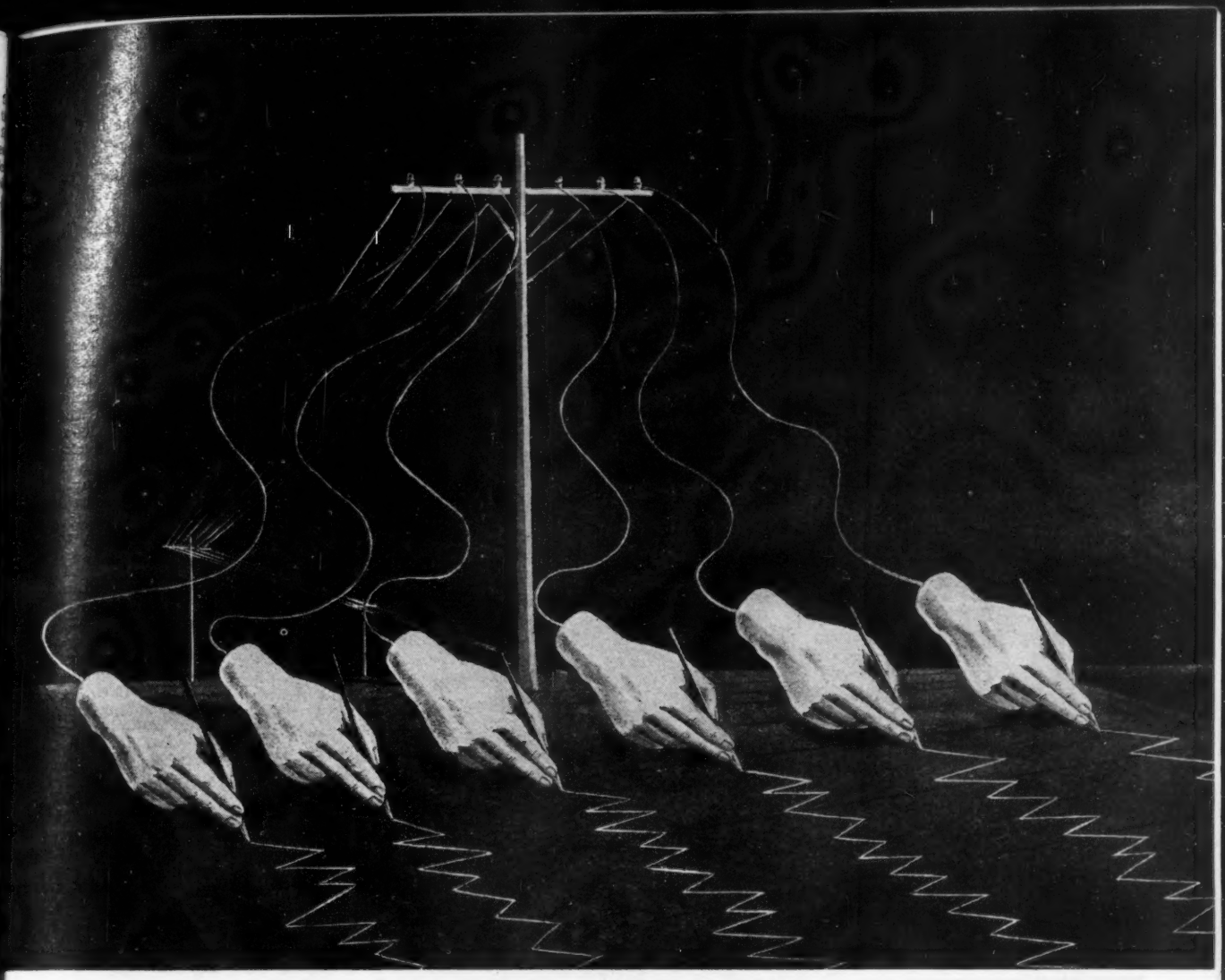
by 1 1/16" diameter. They produce from a low-torque rotational movement a variable electrical resistance. They can be connected directly to sensitive low-torque apparatus such as aircraft flight test recording instruments, and will operate relays or recording systems without the use of amplifiers, and from a simple d-c. source. These resistors are said to represent a great forward step toward simplification of delicate circuit measurements; are particularly useful in laboratory or industrial applications where photoelectric cell and amplifiers were heretofore required. Obtainable in various types from 100 to 1500 ohms, and from 4 to 15 watts, "Autoflight" resistors require but 2 gram millimeters input torque to overcome friction. This low value is secured by use of a jewel-supported shaft, the contact mechanism being "made with the accuracy of a fine watch."—*G. M. Giannini & Co., Inc., 161 E. California St., Pasadena, Calif.*

Non-resonant Capacitors

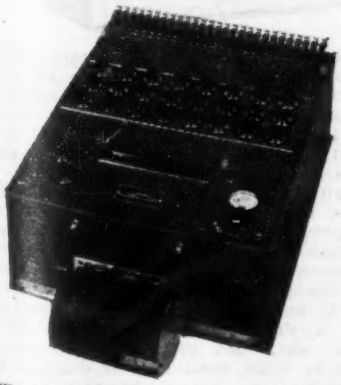
New "Hypass" capacitors are said to be unique in that they do not show resonance at frequencies as high as 50 megacycles and, in many instance, even up to 300 Mc.



As a result, units are of great advantage in the filtering or by-passing over wide frequency bands. Earlier methods of by-passing generally called for use of a paper capacitor shunted by a mica capacitor, or



Type A401R-6 with Battery Case.



Type S-8-A, B, C: 6, 12, 24 channels
(24 channels illustrated above)
Also S-12-A: 12 channels, portable
5-101-A: 14 channels, portable

WRITE WITH LIGHT

For recording dynamic strains and vibrations of *aircraft in flight,* we offer an extremely sensitive and accurate six channel Oscillograph, weighing less than 20 lbs., exclusive of battery, occupying less than ⅔ of a cubic foot of space and selling for only $1500. Operates from its own or the plane battery. Sensitivity is such that many dynamic strains and vibrations can be recorded directly without amplification. Takes hundred foot roll of paper 2" wide operating at one fixed speed, 3, 6 or 12 inches per second.

Write for further details—Type A401 R.

Write for Rental List and Service Manual on business letterhead.

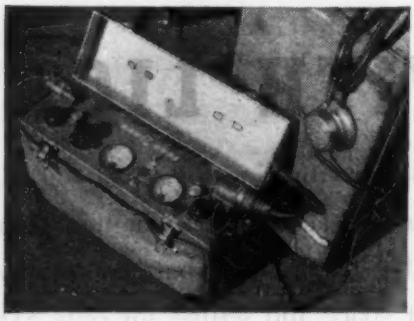
WAUGH *Laboratories*

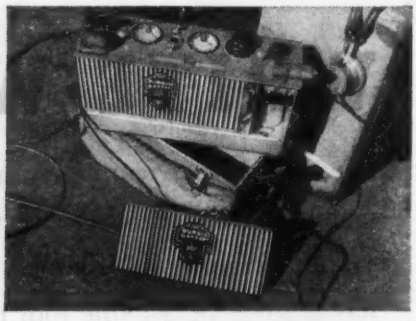
Pacific Coast Branch: 180 East California St., Pasadena 5, California ◆ **420 LEXINGTON AVE., NEW YORK 17, N. Y.**

PORTABLE POWER PROBLEMS

THIS MONTH—PATHE NEWS RECORDING AMPLIFIER

PORTABLE SOUND EQUIPMENT used by Pathe News' Washington staff must be ready for instant action, rain or shine. To meet all requirements of newsreel work, Pathe News engineers developed a lightweight sound amplifier—powered by a special, flat type 180-volt Burgess Battery—with sufficient output in milli-watts to operate the mirror galvanometer. Burgess engineers worked closely with Pathe sound experts to develop this battery (photo lower right).





UNUSUAL ELECTRONIC APPLICATIONS for battery power are the specialty of Burgess engineers. Ask for their help on your dry battery problem. In addition to developing batteries for specific needs, Burgess engineers have made a line of Industrial Batteries so complete that one of the standard types may be ideal for your special requirement. For further information on Industrial Batteries, see your Burgess distributor.

Burgess Battery Company, Freeport, Illinois

BURGESS BATTERIES

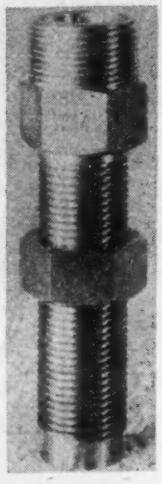
SAVE MORE PAPER—SEND IT TO WAR

Recognized as the MOST COMPLETE LINE of dry batteries

the use of different values of capacity for different bands. "Hypass" capacitors are installed by connecting them in the circuit in the same manner as a low-pass filter would be connected. Their two terminals are connected in series with the circuit and the container is grounded in the usual manner. They may be used to eliminate "hash" in many circuits replacing relatively complicated and bulky filters. — *Sprague Electric Co., North Adams, Mass.*

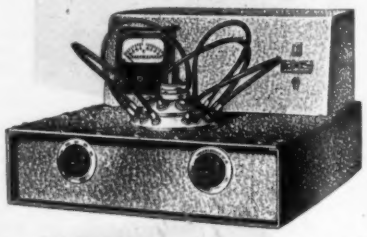
Pressure Pick-up

New "Cox Type 3 Quartz Pressure Element," designed for dynamic pressure study converts mechanical pressures into electrical signals which may be amplified and pictured on the screen of a cathode-ray tube. This new pick-up may be used with auxiliary equipment for studying combustion balance under all conditions of operation, also the effect of changes in carburetor adjustment, and carburetion and ignition characteristics during successive cycles. When used with a properly-designed amplifier, it may be used at approximate frequencies of 10 c.p.s. or higher with inappreciable error. Each unit is given an individual calibration in terms of millivolts per 100 lbs./in.². Average voltage per 100 lbs./in.² is 0.003 volts. Maximum operating pressure, 5000 lbs./in.². Maximum operating temperature, 350°C. Length of unit, 3½". Unit is available in 18—1½ mm. thread. Other sizes can, of course, be fitted with adapters. Unit comes packed in carrying case complete with 5-ft. cable-and-connector assembly and wrenches. Carrying case size, 8¼" × 11¼" × 2½". Gross weight, 5 lbs. — *Commercial Research Laboratories, Inc., 20 Bartlett Ave., Detroit 3, Michigan.*



Capacitance Meter

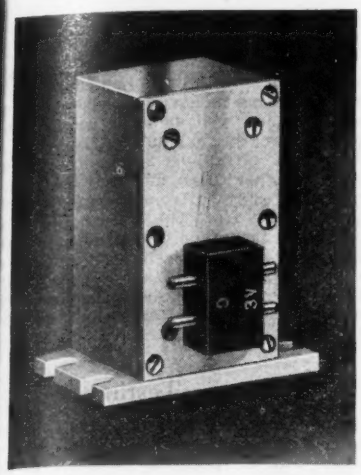
New "Model 37B Capacitance Meter," for low-capacitance measurements, gives direct reading through range of 0.001 to 100 μfd; is said to combine the speed and ease of direct reading on a 6" linear-scale indicating instrument with the accuracy normally associated with bridge measurements. Providing a wholly shielded measuring circuit, this instrument is said to be suited to a variety of precision measurements; is particularly useful in the measurement of vacuum tube interelectrode capacitances, where it is applicable to both laboratory and production testing. Socket adapters accommodating all popular tubes permit measurement in accordance with RMA and JAN standards. An important advantage is said to be its expandable range which allows a single scale to cover the limits within which any group of measurements normally falls. Steel case is designed for operating convenience: the two control knobs are mounted on a recessed front panel just below level of deck on which the test socket is mounted; indicator on



which capacitance is read is mounted on rear panel, which slopes at proper angle for easy reading; this panel also carries pilot lamp and ON-OFF switch.—*Technical Apparatus Co., 1171 Tremont St., Boston 20, Mass.*

Acceleration-type Pick-ups

New series of accelerometer pick-ups have for their sensitive element unbounded strain-sensitive filaments in grid form, which constitute the sole support for the



mass. The filaments are connected in a Wheatstone bridge circuit of which all four arms are active. The bridge circuit is balanced in assembly, so that no external balancing circuits or components are required. There are four electrical terminals, one at each corner of the bridge. A small dry cell battery is connected to two of them, and the other two are connected directly to the recording galvanometer. The method by which the strain-sensitive wires are supported is such that the full efficiency of their strain sensitivity is realized, resulting in an output level so high that no amplification is required. The natural frequencies of these accelerometer pick-ups vary from 100 to 1000 c.p.s., depending upon their acceleration ranges. The "12 *G* Accelerometer" has a natural frequency of 400 c.p.s. and weighs 2 oz. It is believed by the manufacturer that there is no other comparable accelerometer in existence which will drive standard recording galvanometers without amplifiers or electronic carrier equipment. Statham Accelerometers are linear within ½%. Their sensitivity to transverse acceleration is less than 0.1%. They cannot be damaged by excessive acceleration. The zero drift with temperature is less than 1% between + 100°F. and − 50°F. The calibration factor will change less than 3% within this temperature range.—*Statham Laboratories, 8222 Beverly Blvd., Los Angeles 36, California.*

Cathode-ray Tubes and Oscilloscopes

New cathode-ray tubes for industrial apparatus and oscilloscopes for the study and inspection of electrical wave-forms and the measurement of voltages, currents, and

● In maintaining the highest standard of excellence the one and only HICKOK aim must always be the building of instruments that tell all the truth all the time. When quality is built up to a high standard instead of down to a price, the user has greater confidence in his work.

Whether you are selecting tube and set testers, signal generators, oscillographs, volt-ohm-milliammeters or any other service equipment, remember that the standard of quality for a third of a century has never been excelled. Having pioneered the major new developments and vindicated maximum accuracy and dependability, HICKOK equipment has been specified by the armed forces in both world wars. We are still bending every effort to speed the war program and trust it will not be long until we can again take care of your civilian needs with the service equipment that is held in highest esteem. Write for Radio Equipment catalogue.

THE HICKOK ELECTRICAL INSTRUMENT COMPANY
10519, Dupont Ave., Cleveland 8, Ohio

ENGINEERS! DRAFTSMEN! ACCOUNTANTS! STUDENTS!

ORDER TODAY! Sensational NEW

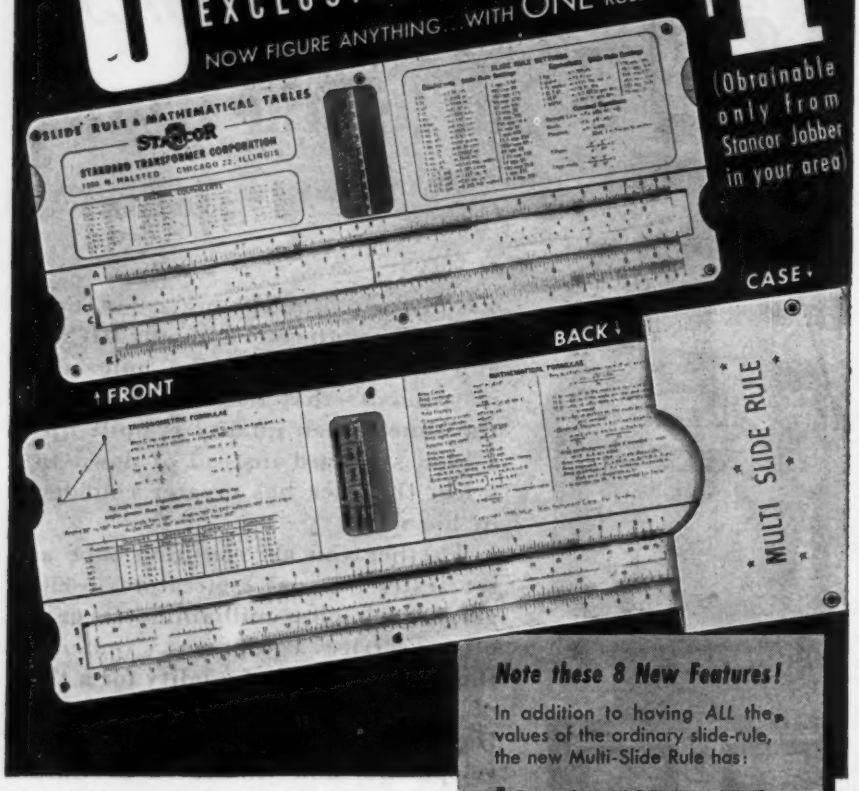
MULTI Slide Rule

WITH 8 ADDITIONAL, EXCLUSIVE TABLES!

NOW FIGURE ANYTHING...WITH ONE RULE!

$1

(Obtainable only from Stancor Jobber in your area)



Note these 8 New Features!

In addition to having ALL the values of the ordinary slide-rule, the new Multi-Slide Rule has:

1. Four-place LOGARITHM TABLE
2. SIGNS and LIMITS of VALUE assumed by trigonometric functions
3. Table of NATURAL TRIGONOMETRIC FUNCTIONS
4. Table of TRIGONOMETRIC FORMULAE
5. Table of SLIDE-RULE SETTINGS
6. Table of GENERAL EQUATIONS
7. Long list of common MATHEMATICAL FORMULAE
8. DECIMAL equivalents of a fraction

Clear, legible print . . . Tough, durable for long wear . . . Size 10" x 4" . . . Fits 3-ring binder . . . In case . . . Full instructions . . . TRANSPARENT PLASTIC INDICATOR . . .

STANCOR now offers the entire electronic industry the new Multi-Slide Rule. First developed for our own use, it is today made available to all . . . Greatly simplifies calculation of unlimited range of problems . . . A genuine professional rule—not a toy. This rule is obtainable ONLY THROUGH STANCOR JOBBERS. PLEASE DO NOT ORDER DIRECT. See your local directory for the name of the Stancor jobber in your city or, write for his name. Price of Stancor Multi-Slide Rule: One Dollar!—America's biggest slide-rule bargain—a service to the trade by Stancor.

STANDARD TRANSFORMER CORPORATION
1500 N. HALSTED ST. CHICAGO 22, ILL.

ORDER FROM YOUR JOBBER

OFFERED AS A SERVICE TO THE TRADE BY

STANCOR

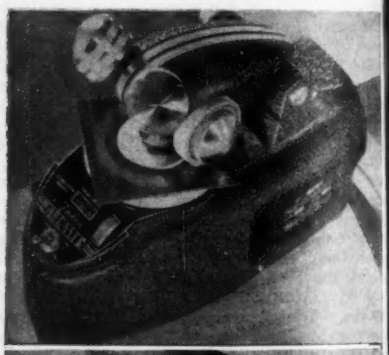
frequencies and many other production and laboratory services are announced. Tubes for replacement and original equipment feature rugged construction, long life and uniform electrical characteristics. Standard "3AP1," "3BP1," "5AP1," "5BP1," "5CP1" and "5HP1" RMA types are glass-produced by modern automatic equipment and similar tubes may be supplied with "P4" or other special phosphors. Coöperation with special designs for unusual or experimental applications is offered.—*Commercial Engineering Dep't., Sylvania Electric Products, Inc., Emporium, Penna.*

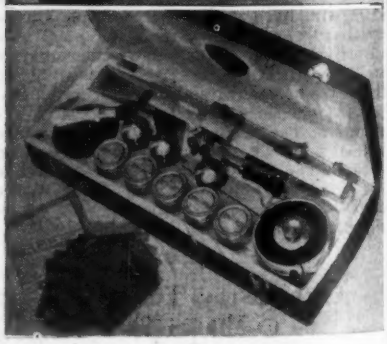
Synthetic Optical Crystals

New synthetic crystals, in sizes much larger than heretofore practicable, permit making prisms as large as 4½" high with 6½" faces, as well as large windows, etc., thereby greatly expanding the fields of infrared and ultraviolet spectroscopy. Purity also is higher than formerly obtainable. Crystals are grown from their molten salts under license from the Research Corporation, using technique developed at Harvard University and Massachusetts Institute of Technology. Available at present are (1) lithium fluoride, (2) sodium chloride, (3) potassium bromide.—*Harshaw Chemical Co., 1945 East 97th St., Cleveland 6, Ohio.*

Abrasion Testing Set

New complete Testing Set includes maker's "Abraser" with all accessories, together with a specimen table for running tests under wet or moist conditions. An illuminated magnifier for inspection and examination of specimens is part of the new set. Wearing action of "Abraser" is performed by dual "Calibrase" wheels bearing against specimen under constant pressure and revolving in opposite directions, one sliding radially toward outside and the other sliding toward inside of wear path. Each wheel revolving at a steady constant speed through contact with specimen exerts a combined abrasive, compressive and twisting action twice in each revolution of specimen holder. Thus, wear due to differences of grain or weave is fully revealed. A standardized load adjustment is provided for varying pressure of "Calibrase" wheels against specimen so that "Abraser" will test both delicate and tough materials with equal precision.—*Taber Instrument Corp., North Tonawanda, N. Y.*





Pressure-gage Tester

New multi-purpose pressure gage tester provides for the first time a single testing unit that can be used with equal facility for bench testing and for portable testing

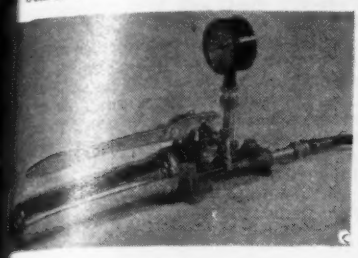


Fig. 1

the field. On bench testing, the unit can be used with test gages or with a dead-weight attachment (see Fig. 2). A doubly-sealed check valve completely eliminates leakage and loss of pressure even with grit in the system, whether using oil or water

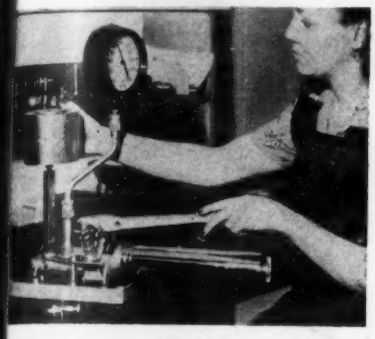
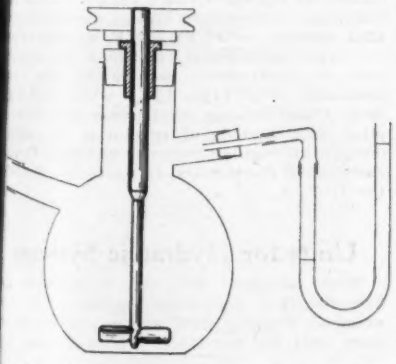


Fig. 2

and for pressures up to 10,000 lbs./in.². Uses of new testing unit include testing and repairing of pressure gages and instruments, setting of relief or other pressure-actuated valves and general hydrostatic testing.—*Mansfield & Green, 4601 Euclid Ave., Cleveland 3, Ohio.*

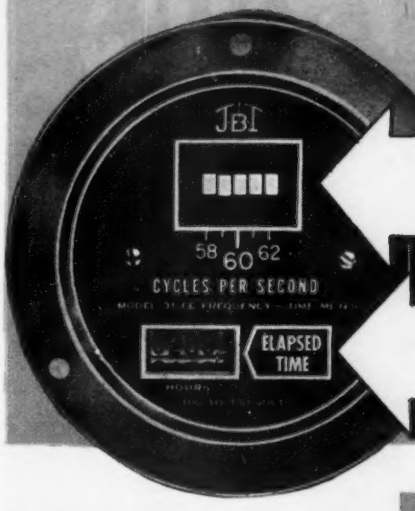
All-Glass Stirrer

New "FS All-Glass Stirrer" facilitates stirring the contents of flasks maintained under low pressure or vacuum, makes it unnecessary to provide a clumsy mercury

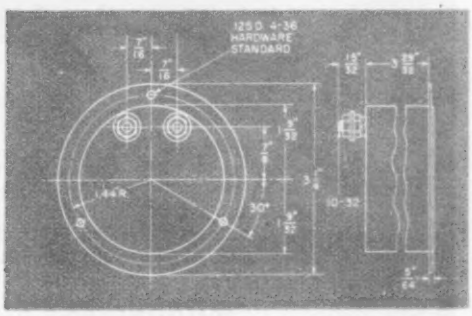


seal to close stirrer shaft against leakage. Stirrer is so accurately made that a pressure difference as great as 60mm. of mercury between inside and outside of the flask causes no leakage of gas around stirrer shaft. No impurities can be introduced into flask, since stirrer is all glass. Accuracy of dimension of inner surface of bearing tube is within ± 1 to 2 microns. If pressure difference reaches 60 mm. of mercury or more, stirrer and shaft may be lifted up in bearing, but even then no leakage of gas is observed. A suitable lubricant improves operation and increases gas tightness. Bearing is of such a nature that

NEW METER Indicates BOTH FREQUENCY ELAPSED TIME



- Saves panel space and weight – one instrument does the work of two
- Insures operation of equipment at proper speed, within ± 0.3%
- Eliminates breakdowns caused by failure to lubricate, maintain and overhaul—on schedule



Size...3¼" flange diameter. Black metal case for flush-panel mounting. 5 reeds...58-62 cycle range. Accuracy... ± 0.3%. Power consumption... 3 watts, 110 volt operation. Weight...1.3 lbs. Also made for 59-61, 48-52, and 49-51 cycle ranges.

This combination running time and frequency meter is just one of the variations J-B-T has pioneered for specific field and laboratory use in measuring speed, temperature and frequency. This and 17 other interesting applications are illustrated in a new bulletin, now ready.

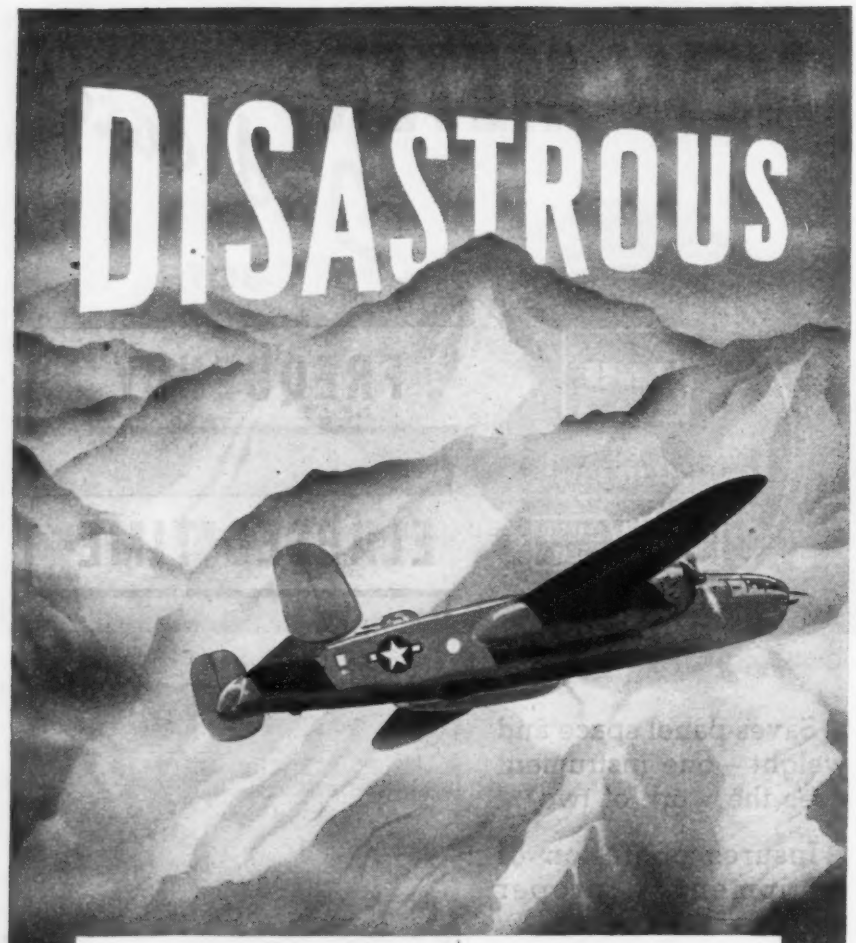
They may suggest ways to attack your own problems... through use of J-B-T's wide engineering "know how," laboratory set-up and production capacity. Ask for Bulletin VF 43-IC.

P.S. Perhaps you would also like to have Bulletins VF-43 describing basic Vibrating Reed Frequency Meters and their operation, VF 43-IA on 400 cycle meters and VF 43-IB on the smallest frequency meters made. They're yours for the asking too.

J-B-T INSTRUMENTS, INC.

443 CHAPEL STREET • NEW HAVEN 8, CONNECTICUT

DISASTROUS



without INSTRUMENTS!

Giants of the air wing their way with assurance through treacherous weather hazards. The pilots not seeing, but depending upon instruments to carry them safely through . . . to seek out the enemy, bomb him with accuracy . . . and to bring them safely home.

This same dependence upon instruments by our flyers is repeated a hundredfold in industry to reach the massive production quotas of war. In peacetime our industrial leaders as well as small business men will rely more and more upon these and other instruments to step up production and eliminate guesswork . . . to test, measure and control quality . . . to locate defects . . . save time and money and perform feats now unknown in research laboratories.

Yes, instruments *will* play an increasingly important part in our peacetime civilization to make a better world in which to live.

Instruments

THE MAGAZINE OF MEASUREMENT AND CONTROL

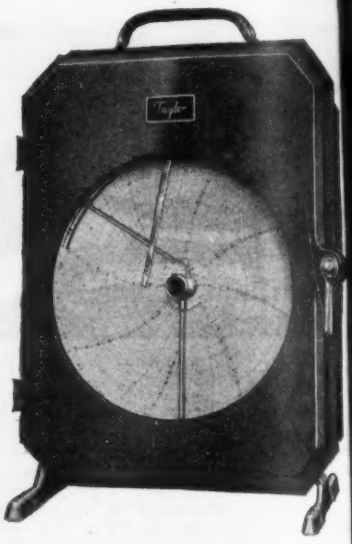
THE INSTRUMENTS PUBLISHING COMPANY • 1117 WOLFENDALE STREET • PITTSBURGH, PA.

This advertisement was prepared for INSTRUMENTS by Frederick Smith Advertising, New York City, advertising agency for Ballantine Laboratories, Boonton Radio Corporation and Measurements Corporation, Boonton, N. J.

at low speeds no lubricant other than li in flask may be necessary, but where h er speeds are required a lubricant (sele to fit requirements) should be used. supplied, apparatus consists of a bea and shaft precisely fitted to each ot Propeller shaft can be lengthened by ing a piece of hard glass rod of ap priate length between propeller and bea shaft, if needed. While speeds of r.p.m. can be used, high speeds natur increase wear on glass surfaces. A m mum of 600 r.p.m. is ordinarily recomm ed and even lower speeds are prefer At 1000 r.p.m., minimum bearing lif 1000 hours. At lower speeds the lif correspondingly greater. — *Fish-Schur Corp., 230 East 45th St., New York 17, N*

Portable Recording Thermometers

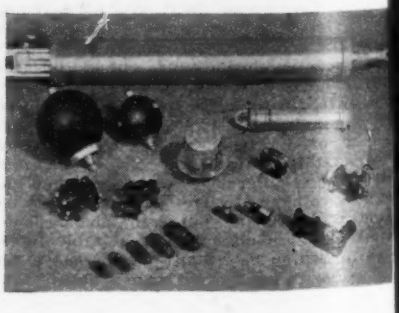
Back on the market: Taylor Port Recording Thermometer. This is a stand Taylor recorder except for the special perature-measuring system and the st



feet and carrying handle which have be added. To assure accuracy, pre-formed cap lary bulb attached to back of case is i sulated in such a way that the record temperature is not affected by the ca temperature. Recorders are available wi numerous standard chart ranges within t following temperature limits: mercury-act ated system, —38° to 200°F. or equivale C.; vapor-actuated, 0° to 300°F. or equiv lent C. Instrument weighs 18 lbs. a measures 20¼" high, 13¾" wide, and 6¾ deep. Chart-driving mechanism can be su plied with periods of revolution to accom modate all regular recorder charts.—*Tayl Instrument Companies, 31 Ames St., Roche ter 1, N. Y.*

Units for Hydraulic Systems

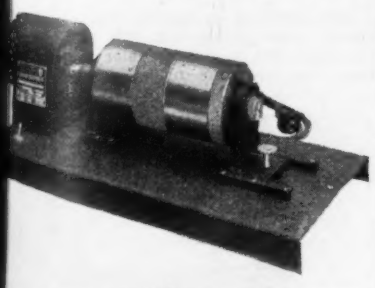
New complete line of equipment f 3000-lbs./in.² hydraulic systems is an nounced. Twenty units are in production soon will be available. Photo shows (a



two actuating cylinders. The 5" and accumulators, upper left. Below these the flow equalizer (left) and pressure ulator. Check valves in foreground. Cenobject is new electrically-operated 4-Selector Valve and to the right is the T.S. 4-way Selector Valve. At far right he Power Brake Valve and below it hand pump. One- and two-way Restrictor es are in center foreground. Units inporate exclusive features such as patd Bendix Plastic Poppet, Flash Welded nder Barrels, continuous Accumulator ls and advanced Flow Equalizer design. *acific Division, Bendix Aviation Corp., 0 Sherman Way, North Hollywood, f.*

Grease Stability Tester

ew "Precision-Shell Roll Tester" (origied by the Shell Oil Co. Wood River Reory, incorporating suggestions by Interional Lubricant Corp.) helps improve



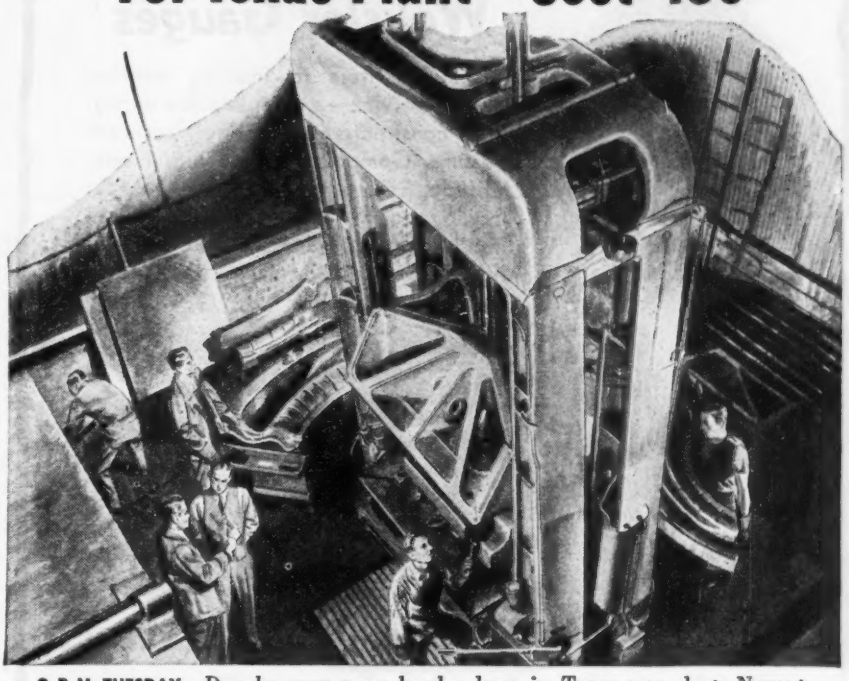
and roller bearing greases by measurthe tendency of a lubricating grease to efy while in service. A weighted iron er enclosed in an iron cylinder rotates 60 r.p.m. for four hours, while roller olves along wall of cylinder, intensely ading the grease sample. Micro penedion is then determined with an alumin micro penetrometer cone of "Shell" ign. Greases showing more than 80 points erence between unrolled and rolled porns are classified as having unsatisfactory ller stability."—*Precision Scientific Co., 6 North Springfield Ave., Chicago 47, Ill.*

Hermetically-sealed Electrical Instruments

New hermetically-sealed electrical indiing instruments with internal pivot conuction are announced in 2½", 3½" and round styles. Dimensions are in accord-

ce with American War Standard Drawg C39.2-1 and C39.2-2. The 4" round truments, for use in radio service equipent where several scale arcs are required, ve a body diameter of 3½", flange diamer of 4½" taking a mounting hole radius 15/16". New instruments include voltters, ammeters, milliammeters and microammeters, both a.c. and d.c., as listed in WS Specification C39.2. All sizes are used in metal cases, hermetically sealed a clamping mechanism which guarantees

Air Express Saves $2,000 For Texas Plant — Cost $180



2 P.M. TUESDAY— Drop-hammer press breaks down in Texas war plant. Nearest replacement part is in the East, over three normal shipping days away. To avoid costly shutdown, the manager telephones for a new part via Air Express, even though the part weighs 250 pounds.

7 A.M. WEDNESDAY — Replacement part lands at Texas airport. Air Express charges were $180. But manager figures a saving to the plant of three precious production days and a saving of $2,000 in overhead by avoiding a shutdown.

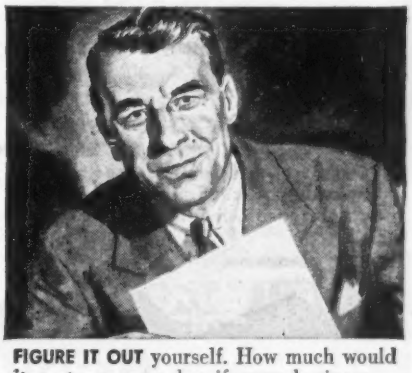


FIGURE IT OUT yourself. How much would it cost you per day if your business — or a part of it — came to a standstill for lack of essential parts or material? Remember, the nation's inventory is within hours of your door, via Air Express.

Specify Air Express — Low Cost for High Speed

25 lbs., for instance, travels more than 500 miles for $4.38, more than 1,000 miles for $8.75, more than 2,000 miles for $17.50, at a speed of three miles a minute — with cost including special pick-up and delivery in all U. S. cities and principal towns. Same-day delivery between many airport towns and cities. Rapid air-rail service to 23,000 off-airline points in the United States. Direct service to scores of foreign countries.

AIR EXPRESS

GETS THERE FIRST

Write Today for "Quizzical Quizz," a booklet packed with facts that will help you solve many a shipping problem. Railway Express Agency, Air Express Division, 230 Park Avenue, New York 17. Or ask for it at any Airline or Express office.

Phone RAILWAY EXPRESS AGENCY, AIR EXPRESS DIVISION

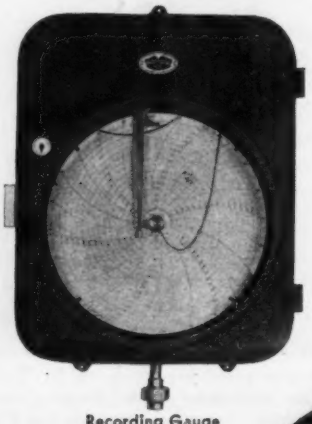
Representing the AIRLINES of the United States

INSTRUMENTS FOR INDUSTRY

Pressure Gauge, Phenol Case

Weksler Gauges

WEKSLER offers to Industry *another* valuable service—a complete line of ruggedly constructed and lastingly accurate Pressure, Compound, Ammonia, Freon, Altitude, Retard, High Pressure and Hydraulic and Recording Gauges—in all Standard Ranges and in the cases and with the various dial sizes listed below.



Recording Gauge

DIAL INDICATING CASES:
PHENOL CONDENSATE
CAST ALUMINUM CAST BRASS
DIAL SIZES: 3½", 4½", 6" and 8½"
RECORDING CASE: CAST ALUMINUM
CHART SIZES: 10" and 12".

Your inquiries as to WEKSLER GAUGES—types of movements, connections, list prices, etc., are solicited. The helpful advice of our Engineering Department is yours for the asking.

Compound Gauge, Cast Brass Case

WEKSLER THERMOMETER CORP.
52-56 West Houston Street
NEW YORK 12, NEW YORK

The ONLY handbook of its kind

MAINTENANCE AND SERVICING
OF ELECTRICAL INSTRUMENTS

By JAMES SPENCER, in charge of Instrument and Relay Dep't, Westinghouse Elec. & Mfg. Co., Newark, N. J.

Reprints available

INSTRUMENTS PUBLISHING CO.
1117 Wolfendale St., Pittsburgh 12, Pa

Enclosed is $..... for ..... copies of Maintenance and Servicing of Electrical Instruments (at $2.00 each).

Name.....

Address.....

City.....

SHOULD be of great value to all those whose problem is to keep in operation the electrical instruments on vital war production as well as on war equipment.

Cloth, xii + 256 pages, 5 × 8¼ inches,

274 illustrations.

Price, $2.00 postpaid

Check, money order or cash must accompany order.

a permanent air-tight joint. All are sealed from the top under pressure by means of clamping rings. Their vacuum seal excludes all moist air which might cause condensation on moving parts. They can also be sealed with dry air at sea-level pressure or with inert gas. Cases are Parkerized and then black enameled. Thick flint-hard glass withstands 25 lbs./in.² pressure. Gaskets are of special synthetic rubber permanently locked. Instruments are vacuum- and pressure-tested under water. Terminals are of special glass soldered-in type using glass-to-metal bond. Movements are of internal-pivot construction for long life and resistance to shock and vibration. Instruments are designed to operate properly at 85°C. High-strength Alnico magnets are used to permit same instrument to be used on steel panels as well as insulating panels. — *Hickok Electrical Instrument Co., 10519 Dupont Ave., Cleveland 8, Ohio.*

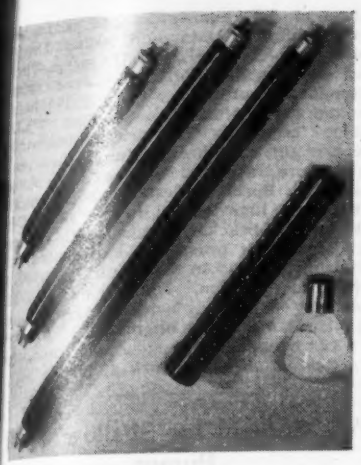
Surface Pyrometer

New surface pyrometer has streamlined plastic case which not only improves the appearance but is much easier to keep clean than the previous metal one and is cor-

rosion-free. While final weight of instrument remains approximately the same, plastic design enables much better balance and "feel." Redesign also simplifies electrical insulation problems and makes possible many mechanical improvements. Unbreakable Lucite window replaces usual glass pane and, since this window extends over top of instrument, scale has better illumination and temperature is more easily read, particularly in half-light. This of course makes for even greater accuracy. — *Cambridge Instrument Co., Inc., Grand Central Terminal, New York 17, N. Y.*

Fluorescent Lamps for Instrument Illumination, etc.

New series of fluorescent lamps for industrial, aircraft and marine instrument illumination and many other applications are for operation on 120-volt a-c. and 24-28-volt d-c. circuits. The near-ultraviolet "B-12," rated at 4 watts, is designed for use with a visible light filter where a light-weight, compact lamp is required. It is equipped with a polarized bayonet base and may be operated in any position for use with aircraft instruments, inspection or other industrial equipment. New red-purple



eries tubular lamps require no visible light lter and operate with standard fluorescent amp accessories on 120-volt a-c. circuits. hey are supplied with miniature bi-pin ases in five sizes ranging from the 6" T5" rated at 4 watts to the 36" "T8" rated t 30 watts. — *Sylvania Electric Products nc., Emporium, Penna.*

Reversible Plug Gages

In new "Dublife Gage," metal collets are eplaced by colored plastic collets—green or the "Go" plug and red for the "No Go" lug. New plastic collet is said to grip the

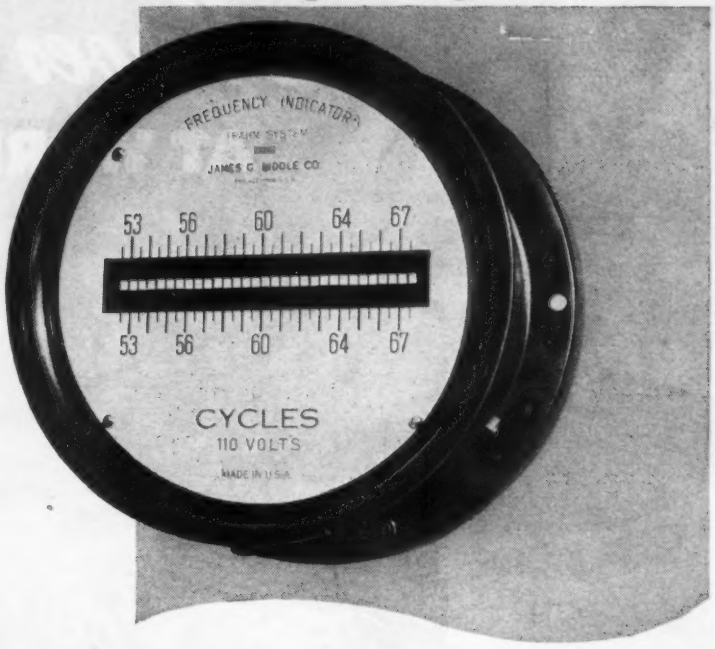
lug with a much more secure hold than oes metal. It is easily removed by use of drift. Weight is reduced by the plastic ollets. An entirely new light-weight handle s so designed that either plug can be uickly removed without disturbing the oth- r plug.—*United Precision Products Co., 8524 W. Belmont Ave., Chicago 18, Ill.*

Hermetically-sealed Resistors

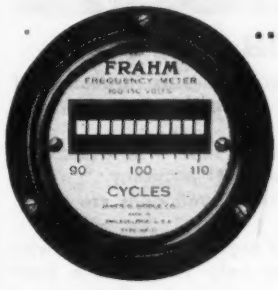
New "Seald-Ohm" resistors are completely-hermetically-sealed precision units originally designed for use in Army and Navy equipment, hence suitable in any equipment

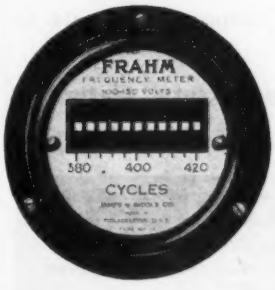
where extremes of humidity and temperature are met. These resistors may be employed as secondary standards, resistor elements in bridge networks, in voltage divider circuits and in attenuation networks. (1) Electrical Data:—Resistor Windings: Spool, or mica-card type. Non-inductively wound. Aged to remove strain before final calibration. Resistance Range: Any desired value: maximum 1,600,000 ohms. Temperature Characteristics: Four types of resistance wire available. Accuracy: ±0.1% to ±10.0%. Frequency Characteristics: No appreciable effect over audio range; range may be exceeded. Circuit Combinations: 2 terminals at one end or 2 terminals at two ends. A single 4-terminal unit is designed to take up to four separate spool-type re-

"FRAHM" Frequency Meters



What are your Frequency Measuring Requirements ...25...60...100...400.....1400 cps?





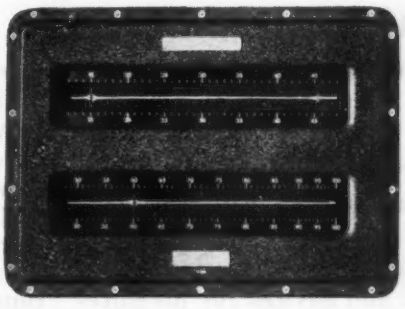
Frahm Frequency Meters in switchboard, miniature and portable types are regularly available for ranges between 15 and 500 cycles per second.

To meet special requirements, our laboratory has designed and built instruments for measuring frequencies as high as 1400 cycles. Such, we find, is possible by means of the same simple and direct resonant reed principle, usually requiring less than 0.1 volt-ampere power input, and without recourse to inter mediate frequency conversion equipment. We believe that even higher frequencies are possible.

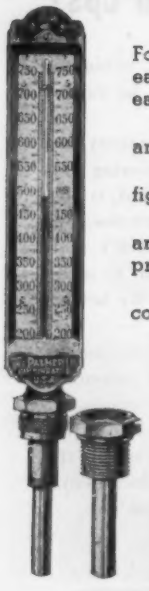
We invite correspondence regarding any frequency measurement problem in the audio and sub-audio range. For its solution we proffer our instruments, our services and facilities. In our 30 years of association with the resonant reed principle as applied to the measurement of frequency, we have been instrumental in the solution of a surprising variety of problems.

Write for Bulletin 1770-I now in preparation.

This instrument was developed for direct indication of frequencies in the lower audio range and for simultaneous direct indication of harmonic components. Called a Harmonic Analyzer, it has unusual electrical characteristics and a wide range, with a total of 288 reeds.



JAMES G. BIDDLE CO. 1211-13 ARCH STREET PHILADELPHIA 7, PA.



EACH ONE HAS A JOB TO DO

For MOM, who has been on the job many years, it means inspection of each Thermometer before it can be shipped and nothing gets by her eagle eye.

For RUBY, it is graduating fine lines on a waxed tube, with great care and precision for each line is important in the final accuracy.

Together they do a grand job . . . while their loved ones are away, fighting for freedom.

It's folks like these, imbued with a spirit of loyalty to our firm, who are responsible for the fine Thermometers that help you make a finer product.

Remember, in post-war plans, only GOOD Thermometers should be considered in rebuilding your future Sales.

1. **Guaranteed Accuracy.**
2. **Easy reading "Red-Reading-Mercury" feature.**
3. **Built for long life.**

(catalog on request)

THE PALMER COMPANY

Mfrs. of Industrial, Laboratory, Dial and Recording Thermometers

2511 NORWOOD AVENUE CINCINNATI 12, (Norwood) OHIO

Canadian Plant: King and George Sts., Toronto

To the Instrument Man With IDEAS

IF you have designs or patents for post-war production and sales, the Post - War Product Service of The Instruments Publishing Company will gladly put you in touch with interested companies manufacturing instruments and devices for measurement, inspection, testing and control.

Write to Post-War Products Service, Instruments Publishing Company, Pittsburgh 12, Penna., giving a brief description of your idea, so that this Service may refer it to the interested companies.

This is not the advertisement of any manufacturer or group of manufacturers, but a notice from The Instruments Publishing Company as a service to its subscribers and advertisers. There will be NO CHARGE to the engineer offering the idea or to the company receiving the leads.

sistors of different values and accuracies. (2) Mechanical Data:— Shielding: Drawn brass, completely hermetically sealed. Thermal shock tested for faulty seals before shipment. Treated to withstand 200 hours salt spray test (f-13 AWS Spec C75.16-1944). Terminals: Electrical connections are brought out through fused glass seals which are soldered in resistor shield. Mounting: Specially-designed steel bracket with spade lugs welded to the sides. Cut-outs on this bracket engaged with embossings on side of brass shield to enable firm mounting of unit in a vertical, inverted or horizontal position. Dimensions: 19/16" wide, 1½" high, ⅞" deep. Add terminal height, 9/16". Studs on mounting bracket 1 11/16" between centers.—*Daven Company, 191 Central Ave., Newark 4, N. J.*

Air Control for Shallow Well Pumps

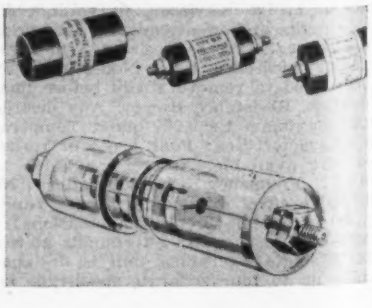
New air control for shallow well pumps is said to be simple, rugged, durable and dependable. Manufacturer announces many features exclusively Ashcroft. They include rubber diaphragm as the single moving part which combines valve head, gland seal and float hinge. Valve has stainless steel orifice and is completely sealed. It has no water cavities. Body is either cast brass or cast iron. Unit is compact, light weight, measuring 1¾" between wrench flats. Control is for applications up to 80 lbs./in.² tank pressure. — *Electro-Mechanical Division, Manning, Maxwell & Moore, Inc., Bridgeport, Conn.*

1-r.p.m. Timing Motor

New self-starting synchronous timing motor is designed for timers, time switches, clocks, fence controls and other applications where the maximum torque and dependability are necessary. Construction is rugged and compact: gear train is sealed in oil separate from the rotor, which is also sealed in its own compartment. Porous bronze graphite bearings assure perfect lubrication. Motor can be furnished with either shaft or pinion gear drive in either direction of rotation in any practical range of speeds. Standard units operate on 110-volt 60-cycle a.c. with 1 r.p.m. output. Overall dimensions of 2" × 2¼" with convenient mounting lugs not shown in illustration.—*Synchronous Products, Inc., 4513 Brooklyn Ave., Cleveland 9, Ohio.*

Hermetically-sealed Resistors

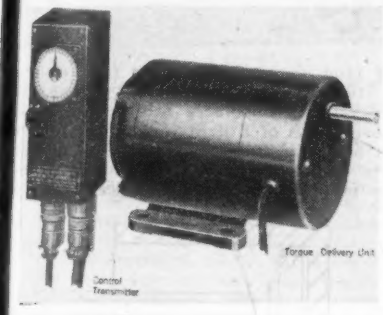
Five new types of hermetically-sealed resistors meet exacting electronic and electrical requirements. Special features of construction are said to assure absolute im-



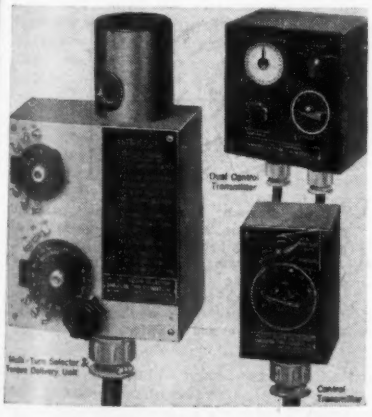
inity to moisture, corrosive fumes and ngus with resultant freedom from circuit se and premature breakdown due to leak- or electrolysis. Sealing-in process con- ts of a wax impregnation and oven de- ration which excludes all possibility of pped moisture or air. Resistor unit itself enclosed in molded Bakelite. Case is in parts with telescope construction at ture. Ceramic spools are used. Mount- of any type is permissible — panel, cket, center band, etc. The five series in production are "RX", "SX", "WX", X" and "BX." "BX" and "CX" units ve 2" No. 18 copper axial leads while others are equipped with 8-32 threaded ds capable of mounting several lugs, es or mounting brackets. The two types mountings (leads and studs) fill all re- irements. Units are tropicalized for hu- d climates and are particularly desirable airborne and mobile installations where ht weight and dependable operation are imary factors. These resistors provide a nge to 1 megohm max. and 2 watts max. andard tolerance 1% ; closer tolerance at ditional charge. All are available wound th Manganin, Advance or Nichrome wire tional. If wound with Manganin or Ad- nce wire, slight additional charge.—*In- rument Resistors Co., 25 Amity Street, ttle Falls, N. J.*

Remote-positioning Systems

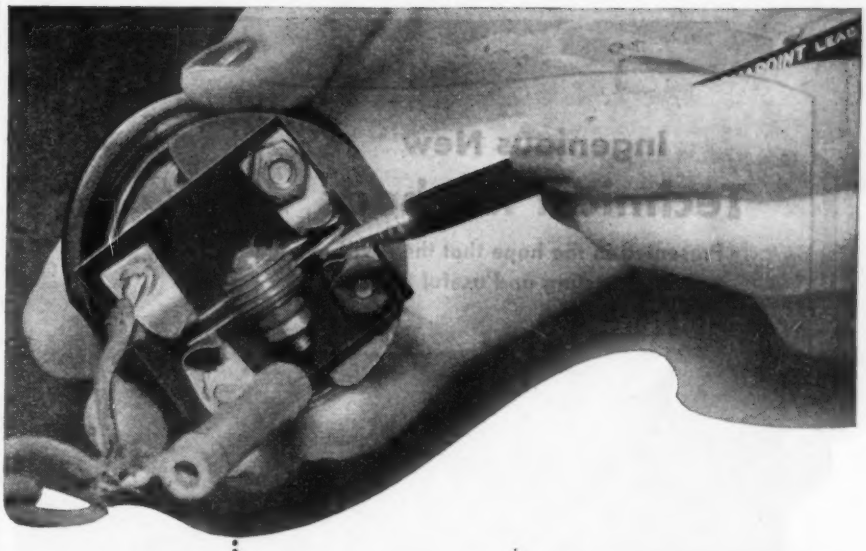
New line of electric positioning devices, own as "A. T. F. Precision Remote Con- ols," has been developed under the Yard- y System. For war-time use, these have



een applied to Navy communications equip- ment, where rigid tests have indicated their eliability under extreme conditions of tem- erature, humidity, vibration and shock. There are four basic types: (1) A Con- inuously-variable Control. This is a non- synchronous follow-up control provided with



a repeat-back indicator for positioning the shaft of a reversible motor to any point of any revolution. (2) A Multi-turn Selector. A motor-driven device whereby its con- nected load may be placed in any one of several (usually six) adjustable positions over one or a number of revolutions. (3) A Dual Control. This incorporates the fea- tures of both the Continuously-variable



still delivering after

88,000 HOURS

96,000

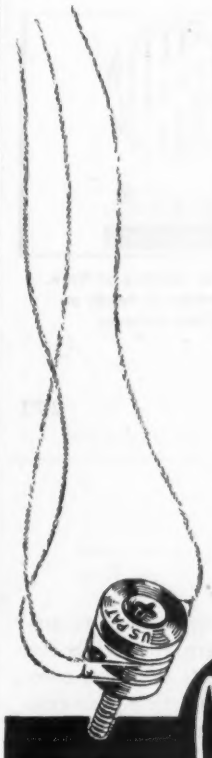
Continuous Service

In July, 1944, we told you the story of this "defective" Conant type M rectifier which we kept in continuous operation in an effort to discover the "defect" a customer had claimed.

This same "defective" Conant rectifier is still operating 24 hours every day after more than eleven years. And, after 96,000 hours, it still delivers its original output.

Since this "time-honored veteran" was built in 1934, Conant rectifiers have been continually improved to make them more dependable. So, wherever accuracy and dependability are important, you can Count On Conant.

Write today *for details about Conant's new rectifier assembly that eliminates temperature variations.*



Instrument Rectifiers

CONANT ELECTRICAL LABORATORIES

6500 O STREET, LINCOLN 5, NEBRASKA, U. S. A.

20 Vesey St., New York 7, New York
85 E. Gay St., Columbus, Ohio
600 S. Michigan Ave., Chicago 5, Ill.
1215 Harmon Pl., Minneapolis 3, Minn.
2017 Grand Ave., Kansas City 8, Mo.
1212 Camp St., Dallas 2, Texas
378 Boulevard N. E., Atlanta, Ga.
4018 Greer Ave., St. Louis, Mo.
1526 Ivy St., Denver, Colo.
4214 Country Club Dr., Long Beach 7, Cal.
Export Div., 89 Broad St., N. Y. 4, N. Y.
50 Yarmouth Rd., Toronto, Canada

Now! Shop Measurements to *One Millionth of an Inch* With Simple Light Wave Setup!

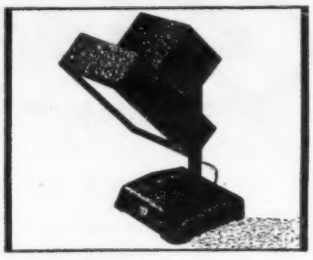
The wave length of light is the basis for this amazing new optical measuring equipment—which measures millionths of an inch as easily as a micrometer measures tenths! All that is required, in addition to a simple setup, is average eyesight, intelligence and arithmetic.

As shown above, the work was placed under the Monochromatic Light, upon the work and gauge block—and covered by the optical flat. The light, reflected back to the operator, by the top and bottom surfaces of the optical flat, creates interference bands, representing height intervals of 11.6 millionths of an inch. So that from the center of one dark band to the center of the next, the level of the work has risen or fallen 11.6 millionths of an inch. The bands, simply, are a contour map of the surface. This fact, in a simple mathematical formula, is sufficient to explain all the shop uses of optical flats, and give the work measurement, quickly and accurately.

No longer, however, can your dealer give you Wrigley's Spearmint Gum. Today, under present conditions, this product cannot be manufactured up to Wrigley's quality standards. To protect consumer and dealer alike, the makers of Wrigley's Spearmint have decided to keep the quality Wrigley's Spearmint wrapper empty. Remember this wrapper, it means chewing gum of finest quality and flavor.

You can get complete information from Acme Scientific Division of Acme Industrial Co., 200 No. Laflin St., Chicago 7, Ill.

Z-70



The Monochromatic Light.

Optical Flat. Surface of Work. Interpretation of bands on truly flat surfaces.

To the Engineer, Physicist or Chemist Who Seeks A PERMANENT JOB

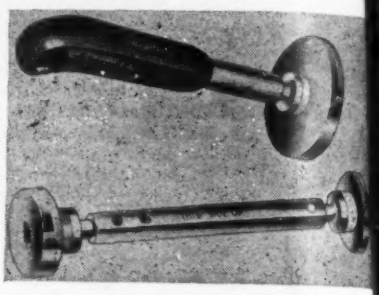
IF YOU are an engineer, physicist, or chemist now working for a company whose war contracts are terminating there may be a permanent job for you with one of the leading instrument manufacturers. Most of these companies are still working full time on war work. As soon as their war contracts are completed, postwar projects will be ready for action with plenty of opportunity for creative development work. Interested? Write Employment Service, Instruments Publishing Company, 1117 Wolfendale St., Pittsburgh 12, Pa., giving complete professional and personal data. U.S.E.S. consent and release statement will be required.

This is not the advertisement of any manufacturer but a notice from The Instruments Publishing Company as a service to its readers. Names will be made available to prospective employers. There will be no charge to applicants or to prospective employers.

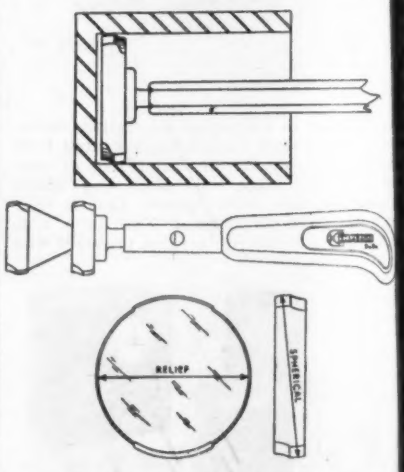
Control and the Multi-turn Selector. this combination, the operator may posit the load to any one of the pre-set positi or, by turning a knob, to any point o the full range. (4) An Integrating Selec This provides automatic setting of the l to a large number of positions by me of a comparatively small number of p buttons. Normal accuracy of positioning c be as close as 0.01° of output shaft. devices are light in weight, small in s and depend entirely on electromechani principles. They are built for any curr characteristics, and their rugged constr tion indicates many desirable applicati in the industrial, marine, aircraft and el tronic fields. — *Remote Control Divisi American Type Founders, Inc., 11 W. 1 St., New York 18, N. Y.*

Plug Gages of New Forms

New "Dubo Gage" is a new form of bo checking gage of the fixed-limit ty claimed to "reveal more about the inter conditions of a bore than any other fo



of plug gage." Small sizes, from 0.240" 1.510" diameter, have the "go" and "n go" gaging members attached to the o posite ends of a light-weight metal handl larger sizes, from 1.510" to 6.010" diamete are single-end gages, individually mounte on palm-fitting plastic handles. Both typ



Upper diagram: Head of "DuBo" gage with relieved sections and chamfers which permit gaging close to bottom of deep blind bores.

Center diagram: Progressive type "DuBo" gage for gaging "go" and "not go" dimensions of through bores at a single pass.

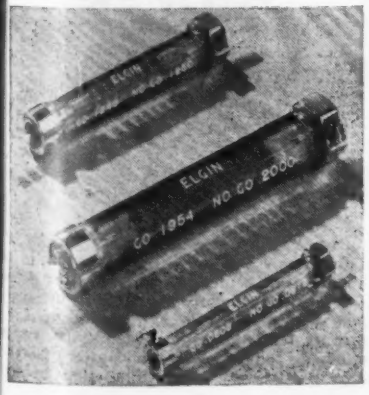
Lower diagram: Cross section showing relief, spherical section and chamfers.

utilize a new color identification system said to eliminate fumbling, wasted motion and risk of errors in choosing proper gage. "Go" members are marked with a broad band of green enamel under a transparent plastic ring; "not go" members are similarly identified by red bands. Handles of the double-end gages also carry corresponding dots of color. Gage head is a relatively thin disk which is a section of a sphere, making contact with bore walls only at instant and point of bore gaging. Two chamfered sections, diametrically opposed on

member, make it possible, by slightly ing handle, to enter gage into bores ly, without risk of marring highly-pol- work piece. A gage without chamfer be inserted in a bore only a compara- short work; "DuBo" can be used to deep bores, as handle need be tilted slightly and does not touch bore walls. sign of gaging members also permits urate gaging almost to bottom of blind es. Chamfered section makes possible inspection of deep blind bores. Cham- edge serves an additional function in ging to wipe away foreign material from ging area, and thus helps to prepare a n surface for accurate gaging. In use, a small portion of gaging surface es contact with surface of bore walls. the "DuBo Gage" may be introduced bores smaller than its diameter, it vides a means for checking out-of-round- s and taper, even when these conditions on the minimum side of the tolerance smaller than the "go" dimension. It is sequently possible to check a back taper part which the conventional fixed-limit e could not enter and to discover faults ich conventional plug gages might bridge. ight of new gages is a fraction of weight equivalent plug gages of conventional e. Thickness of both members of a ble-end "DuBo" is the same, giving balance. Gage members are of highly ped, special alloy steel. It is claimed t wear is negligible and that the "DuBo" outlast chrome-plated conventional plug es. Price is said to compare favorably h that of ordinary plug gages.—*Stand- Gage Co., Inc., Poughkeepsie, N. Y.*

Tenite Handles for Sapphire Gages

Hexagonal Tenite rod stock produced by tinuous extrusion forms the handles of sapphire plug gages. Jewel-like trans- ent red plastic serves as a complement the sapphire "go" and "no go" ends. h appearance of gages commands prop- treatment which further prolongs their e. Hexagonal Tenite handle keeps gage m rolling on a flat surface. Exception- y light in weight, it makes for a sensi- e touch and fine gaging. Being low in rmal conductivity, it does not readily nsmit heat from operator's hand. Both nite and sapphire parts being non-mag- tic, gage may be used without interfer- e near magnetic chucks and steel gaging embers. It is possible, because of the silience and toughness of Tenite, to cure the sapphire parts to the handle by eans of a split threaded bushing with king nut. Lettering and gage specifica- ns are engraved on the handle, buffed, d enameled. Next to diamond, sapphire the hardest substance on the mineral rdness scale. Because of that, sapphire ges can be ordered in the exact size eded, with no wear allowance required. pphire is not affected by any chemical dinarily encountered in gaging. Sapphire ges stand up well under ordinary shock handling in use. Since they are not sub- t to burring, it is impossible to gage



WAR RESTRICTED DEVELOPMENTS

....Now Available....

in Televiso Series 200A Vacuum Tube Voltmeter

TELEVISO, pioneering in the production of measuring apparatus for the *SONIC to UHF SPECTRUM*, has specialized in building dependable Vacuum Tube Voltmeters.

A necessity wherever dependable voltage measurements within the range of 7 cps to 500 megacycles are required—the Televiso Series 200A VT Voltmeter is highly accurate and stable.

FEATURES:

SUPERSENSITIVE RANGE—the lowest readable voltage is .05 volts on a maximum scale range of .5 volt.

FIVE VOLTAGE RANGES—.5, 2, 15, 50, 150—spread full scale on a 4½" meter dial for easy reading. Accuracy of readings are 2% full scale; middle scale accuracy is 5% or better.

PROBE CONSTRUCTION—detachable probe to eliminate cable wear; easily dismantled for tube replacement or for soldering to tube terminals for measurements in the 250-500 MC region; flat ½" wide brass terminals connect to input to make easy soldering to test or work piece; for low frequency work up to 100 MC, removable banana plugs are spaced ¾" center to center for use with standard jacks.

MECHANICAL CONSTRUCTION—of aluminum throughout; panel and cabinet are ¼" thick (cabinet is dural.); subchassis is ⅛" and spaced off the panel by studs to simplify servicing; all components are fastened to sub-chassis.

ELECTRICAL CONSTRUCTION AND CIRCUIT—Series 200A utilizes the finest components throughout and carries a two year guarantee. The circuit is a stable plate circuit rectifier. No diode input tube is used. The plate circuit rectifier type makes available higher input impedance at all frequencies. No shorting of input probe is required for zero adjustments. All zero adjustments are made once and remain constant. A panel adjuster is available to make the unit usable without heating up time. All filament and plate voltages are transformer and tube regulated.

BUILT-IN CALIBRATION VOLTAGE—All units have a jack which produces a constant 6.3 volts for standardizing. This is the regulated filament voltage. The sensitivity can be adjusted without tools in the event tubes are replaced in the field. The Series 200A will operate satisfactorily from any source of voltage from 95 to 130 volts a.c. Line voltage surges are not observable during use.

SIZE—14"H x 9½"W x 7½"D. Guaranteed 2 years. Price $170.00 F.O.B. Chicago.

Televiso Products Inc.

7466 IRVING PARK ROAD • CHICAGO 34, ILLINOIS

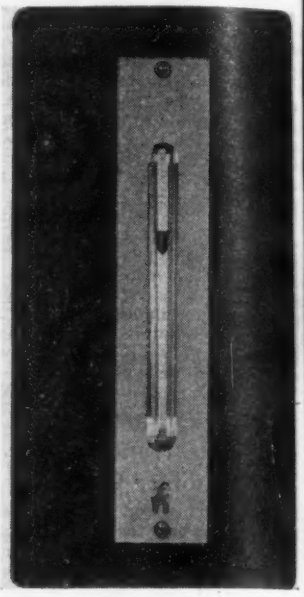
GENERAL ELECTRIC
REGULATED POWER SUPPLY
180-300 volts Type PS-2
For a simple, efficient, economical power supply to replace messy, space-consuming, expensive batteries install a modern G-E Regulated Power Supply. Extremely useful where d-c power is required to operate electronic devices in research or industry. Provides a stable d-c voltage regardless of moderately large or rapid changes in the a-c supply voltage. Other regulated power supplies available in various ranges. Write today: Electronics Department, General Electric, Schenectady 5, New York.
Electronic Measuring Instruments
GENERAL ELECTRIC
164-D6

PRINTERS, LAMINATORS, FABRICATORS OF Plastics
INJECTION AND EXTRUSION MOLDERS
PLASTIC PRINTING by special inks and special methods developed in our plant.
LAMINATION of printed sheets on one or both sides, permanently sealing the printed surfaces.
SHEET FABRICATION on even the most complicated jobs.
Write for Free Booklet A, "Hopp Plastics Today & Tomorrow"
THE HOPP PRESS
INCORPORATED
460 W. 34th St., New York 1, N. Y.
PAT. APPLIED FOR
HEMGAR COMPANY
PHILADELPHIA, U.S.A.
MAINE COAST BOATS
BOSTON BOAT & ENGINE CO.
PRESTO RECORDING CORP. NEW YORK U.S.A. STROBOSCOPE

parts inaccurately as a result of unnot damage to a gage. "No Elgin sapphire g has yet worn out." Complete sapphire g are available from *Sapphire Products vision, Elgin National Watch Co., Aur Ill.* Sapphire plug gage handles are extr ed by *Sandee Mfg. Co., Chicago, Ill.* Tenite used is a cellulose acetate butyr product of *Tennessee Eastman Co Kingsport, Tenn.*

Panel-mounted Rotameter

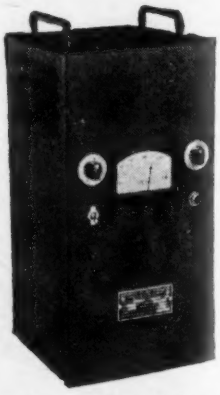
New Schutte & Koerting Panel-mou Rotameter is designed to answer the gr ing need for panel centralization of ins ments that indicate pressure, flow, tem



ature, etc., and offers several advanta Although instrument itself is basically S-K Universal Rotameter, the panel-mo has a frosted glass window with a cent clear-glass aperature and is installed fl in the panelboard, with the Rotameter s ported directly behind. Provision is m for adequate backlighting and ready ma tenance accessibility.—*Schutte & Koert Co., 1169 Thompson St., Philadelphia Penna.*

1- and 2-kva. Voltage Regulato

New "4101" and "4102" models "SECO" automatic voltage regulators h ratings of 1 kva. and 2 kva. respectiv Although these new models are small

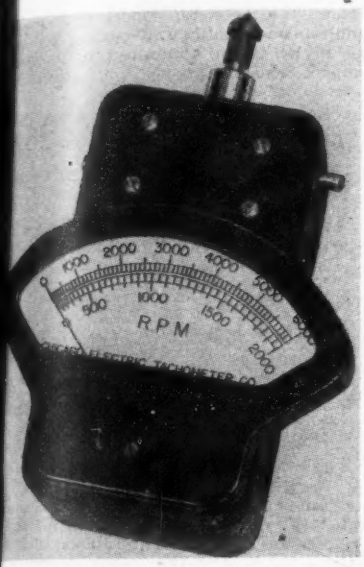


light-weight, basic design of larger "SEC regulators is incorporated: Thyratron tu circuit controlling a variable transform to maintain a constant output voltage r gardless of variations in input voltage output load current. Regulators are n affected by changes in power factor load and there is no distortion in wa

of output. For mounting regulators in ting equipment, these new models are lable on a relay rack panel; for table wall mounting, regulator is housed in net. Both rack and cabinet types are plied with voltmeter, "on-off" switch, itivity control knob and output voltage tor knob mounted on front panel for of operation.—*Superior Electric Co., tol, Conn.*

Hand Tachometer

ew "Model 5-E" Tachometer can be op- ed in close quarters by lightly pressing rubber-tipped shaft against revolving or ing object; is so designed and construct-



that normal machine vibrations do not erfere with readings. There is no internal aring of any kind. Double-range scale: ess side button to change ranges. achometer can be furnished with wheel measuring surface speeds. Overall body mensions: 2⅝" × 2⅞" × 5".—*Chicago ectric Tachometer Co., 800 North Clark , Chicago 10, Illinois.*

Pressure Switch

New "Hi-Pressure Switch" is described a pressure detector particularly adapt- le for hydraulic systems for controlling ydraulic pressures and cutting off circuits predetermined pressures, and for con- oling surge loads. This switch is capable

Announcing... a series of High Vacuum Diffusion Pumps for Industrial Use

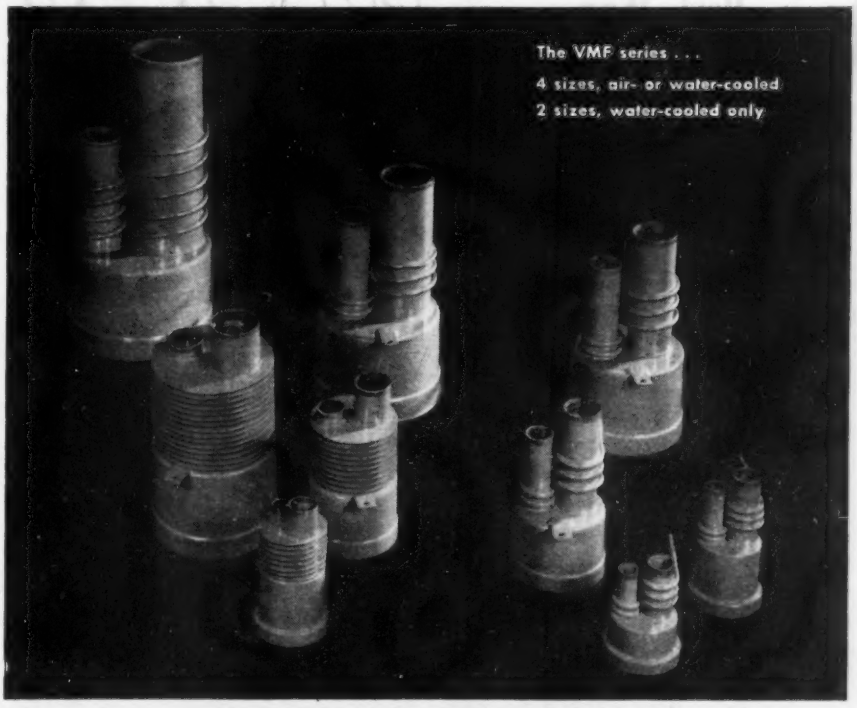
THE VMF SERIES of all-metal pumps embodies an entirely new application of the fractionating, self-conditioning principle. Six different sizes, varying in their range of pumping speeds, make available a model which will fit your particular problem with maximum efficiency. Sturdy in construction, these pumps meet the exacting demands of industry for compact, reliable units, capable of reaching pressures of 10^{-6} mm. of mercury or lower.

The VMF oil diffusion pumps are suitable for use on automatic exhaust machines, electron microscopes, continuously evacuated X-ray tubes, and a variety of electronic devices and production units. They are also suitable for laboratory and other vacuum systems of moderate size where an inexpensive metal pump may be effectively employed.

CHARACTERISTICS	VMF 2	VMF 5	VMF 10	VMF 20	VMF 50	VMF 100
Speed (L/sec.)	2	5	10	20	50	100
Height	3¾"	5¼"	7"	9¾"	11"	14½"
Width	2½"	2¾"	3⅞"	5¼"	6¼"	7¼"
Required fore-pressure, microns..	100	100	100	100	100	150

Ultimate vacuum 1 x 10^{-6} mm. Hg with Octoil

For details concerning these pumps, as well as 20 other types of diffusion pumps, low-vapor-pressure fluids, greases, vacuum gauges, control circuits, and other items for high-vacuum technology . . . ***write Vacuum Equipment Division.***



DP INC. HIGH-VACUUM HEADQUARTERS

DISTILLATION PRODUCTS, INC.

Jointly owned by EASTMAN KODAK COMPANY and GENERAL MILLS, INC.

ROCHESTER 13, N. Y.

AGASTAT

ELECTRO-PNEUMATIC RELAY

COMPACT:
4 IN HIGH
2⅞ IN DEEP
2⅞ IN WIDE

WEIGHT:
1½ POUNDS

ELIZABETH A'G'A NEW JERSEY
AMERICAN GAS ACCUMULATOR COMPANY

of withstanding 3,000 lbs./in.² surge l with a range of adjustment from 10 2,000 lbs.; with a 20-lb. differential at lb. pressure which increases proportiona at higher pressures. Electrical capacity this switch is 10 amps. at 125 volts Contact arrangement is s-p. d-t. Switch provided with either an Amphenol conn tion or a standard conduit fitting. Press connection can be either ⅜" or ½" sta ard pipe thread. Switch weighs appro mately 2 lbs. depending upon the type fittings. — *Pressure Switch Division, C Electric Co., 2700 Southport Ave., Chic 14, Illinois.*

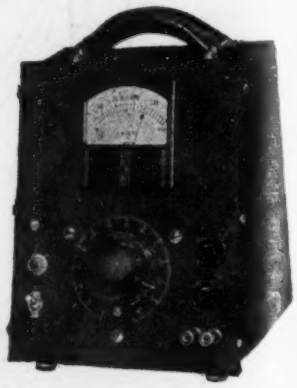
Voltammeter

New "Voltammeter Model 601" perm simultaneous readings of current and v age to be taken. Contained in its stur compact case are an a-c. voltmeter and

a-c. ammeter, ready for instant use. A meter (at right) measures from 0.2 to amperes in eight current ranges: 0-1, 0-10, 0-25, 0-50, 0-100, 0-250, 0-500. Ve meter (at left) measures from 30 to volts in three ranges: 0-150, 0-300, 0-6 Voltmeter can also be used on direct c rent at these ranges. An inserted prima current transformer with 8-ft. seconda leads facilitates measurement of current the 0-100, 0-250, and 0-500 ampere scal without subjecting instrument to str magnetic fields: user can locate the instr ment where it can easily be read, regar less of current transformer's location. Ran selector switch on panel permits quick rea ing of currents in all eight ranges. Met case is provided with a carrying strap. Si of case 12½" × 9½" × 10". Weight packe for shipment, 25 lbs.—*Associated Researc 231 South Green St., Chicago 7, Illinois.*

Variable A-c. Voltage Source

New "Powerstat Voltbox" provides convenient and easy method of obtainin variable a-c. voltage in laboratory, in main tenance shop and on assembly line; elim nates bother and delay in collecting an setting up separate instruments when som voltage other than line voltage is required By connecting "Voltbox" to a single-phas



Post-War Clock Movements *by* CHELSEA

Our production of special clock movements and clockwork mechanisms for recording instruments must wait until this war is won. Meanwhile, we would welcome the opportunity of working with you in developing your post-war designs.

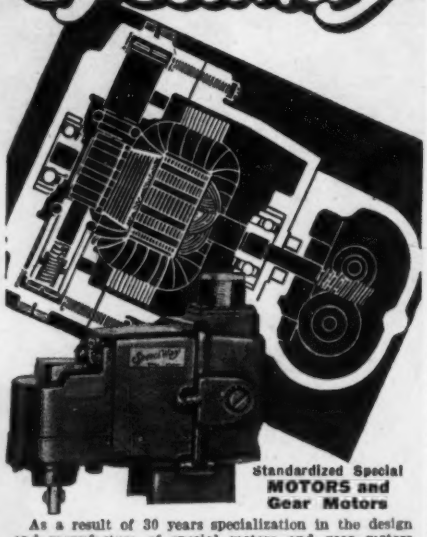
Remember, Chelsea has been making special movements for recording instruments for many years.

ARMY E NAVY

Buy Another Bond Today

CHELSEA CLOCK COMPANY
385 EVERETT AVE., CHELSEA 50, MASS.

SpeedWay



Standardized Special **MOTORS and Gear Motors**

As a result of 30 years specialization in the design and manufacture of special motors and gear motors of from 1/3000 to 1/3 h.p., Speedway has developed not only a vast store of "know how", but innumerable standardized units which can be assembled and wound in varying combinations to give shaded pole, shunt wound or series wound motors, engineered to exactly meet specified requirements of output, torque, space, speed and even cost.

With these standardized parts and units, augmented by over 3000 different gear combinations, SpeedWay can often supply highly special motors and gear motors at standard motor prices.

If you have a war or post-war motor problem, send for the SpeedWay Motor Catalog.

SAMPLE MOTORS OF TYPES NOW IN PRODUCTION DELIVERED PROMPTLY

SPEEDWAY MANUFACTURING CO.
1839 SOUTH LARAMIE AVENUE, CICERO 50, ILL.

Crystals for the Critical...

Headquarters for SPECIAL Crystals!

The men of The James Knights Company have been designing and making special precision crystals since 1932. Their extensive experience with crystals for every conceivable purpose, coupled with an active participation in Radio dating back to 1913, is available to you. These men are interested in your special crystal problems — they have the knowledge, equipment and research facilities to help you. Why not get them working on your special crystal problem today?

JK CRYSTALS

The JAMES KNIGHTS Co.
SANDWICH, ILLINOIS
Sixty Miles Southwest of Chicago

High-Voltage CONTROLS

★ The ingenious Clarostat Series 60 Hi-Voltage Coupler provides either 3,000 or 10,000 volts breakdown insulation between the control proper and its shaft and mounting.

This coupler is available with Clarostat Midget Controls Series 37 (composition-element) and Series 43 (wire-wound). Also with the large Series 58 wire-wound controls. Likewise with Clarostat multiple controls.

Especially desirable for controls used in high-voltage circuits such as television equipment, cathode-ray oscillographs, and many electronic applications.

Neat. Unit mounts as readily as usual control. And SAFE where high voltages are involved.

★ **Submit that problem...**

If it has to do with resistors, controls or resistance devices, send it to us for engineering aid, suggestions, quotations.

CLAROSTAT Controls and Resistors

CLAROSTAT MFG. CO., Inc. · 285-7 N. 6th St., Brooklyn, N. Y.

WHEATSTONE BRIDGE

Rubicon Wheatstone and Kelvin Bridges are available in a number of types to suit various applications. All are made in accordance with the highest traditions of the instrument maker's art and are fully guaranteed.

Described in Bulletin 100 which also lists Rubicon Resistance Boxes and Shunts as well as NBS and Reichsanstalt Resistance Standards.

Copies available on request.

RUBICON COMPANY
Electrical Instrument Makers
Ridge Ave. at 35th St. Philadelphia 32, Pa.

Thermowells
Specially Designed for the OIL and CHEMICAL INDUSTRIES.
Write us your requirements.
Folder of standard types sent on request.

TRINITY
EQUIPMENT & SUPPLY CO.
136 LIBERTY ST. NEW YORK 6, N. Y.

NOW!
BURGESS
THINSTRIP MAGNESIUM
AS THIN AS .005"
IN COILED-STRIP FORM

THIS NEW DEVELOPMENT is now available for production applications from Burgess rolling mill facilities. It can be supplied in widths from ¾" to 5" and from .010" to as thin as .005".

COMPLETE INFORMATION — technical specifications, cost figures, sample strip, and the answer to your problem — is available free in new folio.

Sample on request. Write Dept. M-5

BURGESS BATTERY COMPANY
FREEPORT, ILLINOIS

NEW MODEL
HIGHEST ACCURACY
CHRONOMETRIC
TACHOMETER

Readability to 1 RPM per division. Guaranteed accuracy well within ½ of 1%. Indicates RPM directly on the dial without any calculations over a fixed period of 6 seconds. Negligible torque. Two models with ranges 0-1000 RPM or 0-10,000 RPM, each suitable for double rated range.

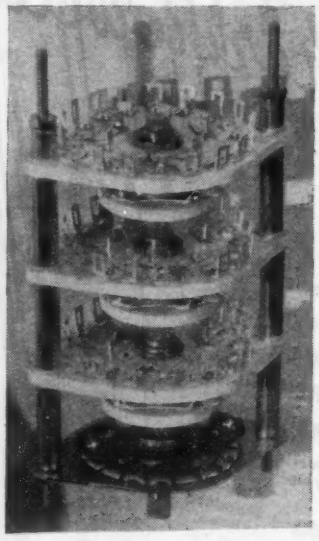
Write for bulletin No. 715.

HERMAN H. STICHT CO., INC.
27 PARK PLACE NEW YORK, N. Y.

outlet, an output variable from zero to considerably above line voltage can be obtained. Accurate voltage setting is assured by an easily-read 1% voltmeter. Beside "Powerstat" variable transformer and voltmeter, other features are a dial light, output receptacles, binding posts, and an input cord and plug. A circuit breaker mounted on front panel prevents over-loading, also serves as an "on-off" switch. Two type numbers of "Voltboxes" prefixed with the letter "U" show that the models described are unregulated; these are "Model U-1000" which operates from a 115-volt line to deliver an output variable from 0 to 135 volts at 7.5 amperes; and "Model U-800" which has twice the voltage rating and an output current of 3.0 amperes. When incoming line voltage fluctuates to the extent that it is impossible to set and hold the voltage to a prescribed value, "R-500 Regulated Voltbox" is recommended. It is similar to unregulated type except that a voltage stabilizer is included. This means constant voltage at any value of output. It is designed for operation on 115-volt lines with a maximum output of 500 va. — *Superior Electric Co., Bristol, Conn.*

Medium-duty Power Switches

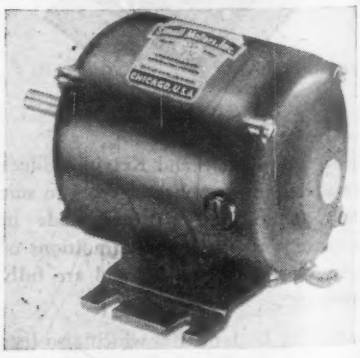
New "J Series" switches for power applications are available from stock in one to five sections, with shorting or nonshorting type contacts. In addition to complete units, sections and indexes are available separately for individual assembly in any desired combination. Switching combinations for the present are one-pole, 17 positions (18 positions, continuous rotation, with eighteenth position "off") and 3-poles, 5 positions (6 positions, with sixth position "off.") All units furnished with adjustable stops for limiting the desired number of positions. Switches have single-hole bushing mounting. In addition to this, tie-rod extensions at both front and rear of switch to serve as locating keys and to offer additional support in mounting. Locknuts, lockwashers and a 2¼" bar knob furnished with each unit. Bar knob has double set screws for secure mounting to



shaft. Units have a double-roller index with minimum life operation of 25,000 cycles. Contact buttons are solid silver, and the terminals lug type. Switch is rated at 7½ amperes at 60 cycles, 115 volts. Minimum voltage breakdown between critical points, 3000 volts rms. Stock items are to be furnished with cadmium-plated, steel and brass parts, but units can be made special in non-corrosive metals and steatite parts can be tropicalized to prevent fungus growth— *Centralab Div. Globe-Union Inc., 900 East Keefe Ave., Milwaukee 1, Wis.*

Fractional-horsepower Universal Motor

New "SM-4 Fractional H.P. Motor" is said to provide maximum power per ounce of weight and per inch of space with long life and dependable performance for Signal



Corps, aircraft and other military requirements and for a wide variety of industrial and domestic purposes. It is available in 1/50-h.p. to 1/10-h.p. ratings. Dimensions: 3-5/16" diameter, 4-13/16" long, height with rigid base 3⅞". Weight 3 to 4 lbs. depending on rating and type of mounting. Motor may be wound for any voltage from 6 to 250, is made in shunt and series windings for direct current, also made universal to operate on either direct or alternating current. —*Small Motors, Inc., 1308 Elston Avenue, Chicago 22, Illinois.*

HARDNESS TESTING...

done WITH NO MENTAL HAZARDS. The SCLEROSCOPE has done it for the past 36 years.

In general use for specification purposes. Simple, sturdy. Comparatively inexpensive.

•

Illustrated bulletins free.

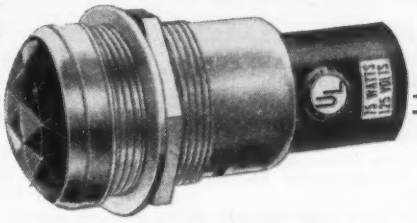
The Shore Instrument & Mfg. Co., Inc.

9025 Van Wyck Ave., Jamaica, N. Y.

Rugged! NEVER NEEDS REPLACING . . .

The new Drake No. 75AP (Underwriters Approved) is an outstanding addition to the Drake line of better Socket and Jewel Light Assemblies. The No. 75AP is rugged . . . never needs replacement. Solder terminal design makes connections absolutely secure . . . no danger of vibrating loose as with screw type terminals. No parts can rotate with respect to one another, nor can the bakelite housing be pushed or pulled from the mounting tube. After once being assembled, the whole unit is one rigid piece. Designed for 110 volt circuits, Special Resistor adapts it to 220 volt circuits, if desired.

Write for full details on the No. 75AP, and on the Drake S6 Lamp Remover. Anyone who maintains or installs large numbers of S6 Lamps will find this remover a great convenience.



The New Drake No. 75AP

DRAKE

SOCKET AND JEWEL LIGHT ASSEMBLIES

DRAKE MANUFACTURING CO.

1713 WEST HUBBARD ST., CHICAGO 22, U. S. A.

PYRO THE SIMPLIFIED OPTICAL PYROMETER

SAVE TIME AND MONEY!

By using PYRO, a self-contained, DIRECT READING, sturdy unit made to stand rough use. It is absolutely accurate and dependable, and quickly pays for itself.

Unique construction enables operator to rapidly determine temperature even on minute spots, fast moving objects, or smallest stream; no correction charts, no accessories, no maintenance expense. Special "FOUNDRY TYPE" and "Universal TRIPLE RANGE" have, in addition to standard calibrated range, a red correction scale determining TRUE SPOUT and POURING TEMPERATURES of molten iron and steel when measured in the open.

Stock ranges 1400° F. to 5000° F.

Write for Catalog No. 80

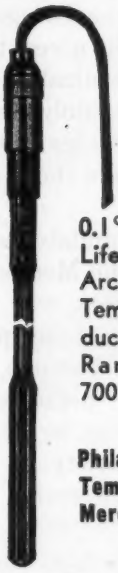
Immediate Delivery for Defense Plants

THE PYROMETER INSTRUMENT CO.

Plant & Lab
103-107 LAFAYETTE ST., NEW YORK, N. Y.

In Canada, Sales and Repair Laboratory:
Dominion Flow Meter Company Limited
Toronto and Montreal

Philadelphia Merc-to-Merc Thermo-Regulators Feature



Mercury to Mercury Contacts : Increased Contact Capacity : Sensitivity within 0.1°F. Exceptionally Long Life and Stability : No Arcing : No Oxidation : Temperature Lag Reduced : Temperature Ranges adjustable to 700°F.

•

Philadelphia Merc-to-Merc Temperature Controls and Mercury Plunger Relays

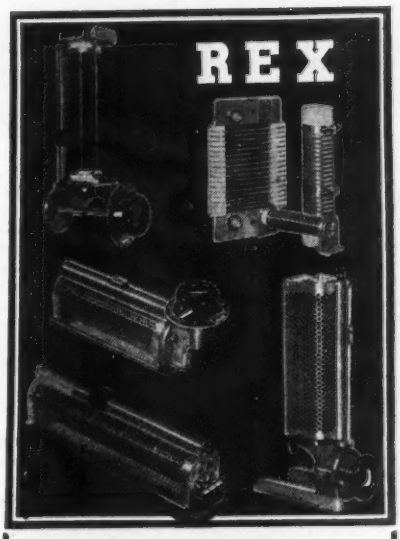
•

The Philadelphia Thermometer Co.

Sixth & Cayuga Sts. -:- Philadelphia

WRITE FOR CATALOGUE No. 104.

Oldest Thermometer Manufacturer in Philadelphia



PROTECTED and UNPROTECTED

TUBULAR SLIDE-CONTACT RHEOSTATS

WITH SELF-LUBRICATING CONTACT BRUSHES

ADJUSTABLE RESISTORS

PROMPT SHIPMENTS

REX RHEOSTAT CO.

BALDWIN, L. I., N. Y.

Instrument Societies

CLEVELAND

At the May 25, 1945 meeting of the Cleveland Instrument Society, the officers elected for the year 1945-46 were installed.

The officers are as follows: Mr. Wm. Sachse, Head of the Instrument Department of Standard Oil Co. of Ohio, Chairman; Mr. Otto Heyman, Meriam Instrument Co., Vice Chairman; Mr. A. J. McCullough, Field Engineer Brown Instrument Co., Secretary; and Mr. Mandel Estrin, National Advisory Committee on Aeronautics, Treasurer.

The outgoing officers will act in an advisory capacity with the new executive committee during the coming year.

—WARREN A. STUBBLEFIELD

HARTFORD

The Hartford Society for Measurement and Control concluded this season's activities with our May meeting at which Mr. Willis F. Hickes of the Foxboro Company, Foxboro, Mass., gave us an interesting talk on "Temperature Measurement and Control."

We have also had our election of officers with the following results: *Chairman:* Stanley G. Johnson (Johnson Gage Company); *Vice Chairman:* William H. Gourlie (W. H. Gourlie Company); *Secretary:* Gustave L. Manke (Veeder-Root Company); *Treasurer:* Robert D. MacGregor (Whitney Chain and Mfg. Co.).

Similarly, the president has appointed the following Committee chairmen: *Constitution and By-Laws:* Joseph J. Ferri (American Bosch Corporation); *Membership:* Carl W. Moeller (Pratt & Whitney Division); *Publicity:* Archie McDougall (Pratt & Whitney Aircraft); *Entertainment:* Alford H. Johnson (Pratt & Whitney Division).

Advisory Committee: Raymond K. Hellman (Connecticut Telephone & Electric Division); Steven J. Zelle (Bridgeport Thermostat Co., Inc.); Donald E. Anderson (J-B-T Instruments, Inc.).

—G. L. MANKE, *Secretary*

KANSAS CITY

At the May 22 meeting of the Kansas City Industrial Instrumentation Society, the report of the first meeting of the Instrument Society of America which was held on April 28 at Pittsburgh was read to our membership. It was announced that our society had already sent the required $10.00 initiation fee and that we were one of the charter sections.

Karl R. Bobb of North American Aviation presented a fine basic lecture on the theory and application of the various types of voltmeters, ammeters and wattmeters.

Our Quiz Kids, R. B. Cook of Westinghouse Manufacturing Company, Walter Brauer of Phillips Petroleum Company, and Roy Carns of Sinclair Refining Company, were finally "stumped" on the question asked by George Agin of Sheffield Steel Corporation. However, Karl Bobb came to their rescue and will see that George's question is answered to his satisfaction within the next few days.

Lester Johnson introduced Clayton Dial, Personnel Director of Sinclair Refining Company, who showed us a swell sound picture on the "Development of the Oil Industry." In addition, Clayton showed several news shorts and a picture with Bob Hope in "Command Performance."

It was announced that our last meeting before summer would be a dance at the Santa Fe Hills Country Club with Earl Coleman's orchestra. This will take place Friday night, June 22, rain or shine, from 8 to 12 midnight. Members are urged to attend and bring their guests. A good time for all is assured with R. B. Cook acting as our M.C.

W. A. REICHOW, *President*

LOS ANGELES

The May regular meeting of the California Instrument Society was held on the evening of May 1st at the Chapman Park Hotel in Los Angeles.

The speaker of the evening was Mr. Sam Levin, of Louis Levin & Son, who gave a talk on the manufacture of Jewel Ring Bearings. Mr. Levin covered in detail every step in the manufacturing operation from the rough blanks of synthetic sapphire to the finished mounted bearing ready for the instrument manufacturer to install. The talk was profusely illustrated by blackboard sketches, at which Mr. Levin was very proficient.

Following the talk, a reel of sound film was shown through the courtesy of the New Departure Division of General Motors Corp. on "The Care and Handling of Micro Instrument Bearings."

The dinner was attended by forty-one, with over sixty members and guests being present at the technical meeting.

—M. D. PUGH, *Secretary*

PITTSBURGH

The May 28th meeting of American Society for Measurement and Control was attended by fifty members and guests at dinner and one hundred at the technical meeting.

Mr. P. G. Exline served as chairman and called for report from the Nominating Committee which was submitted by M. S. Jacobs, chairman. The nominations are as follows: President, Paul Exline; vice president, Sam Prince; secretary, L. M. Susany treasurer, C. E. Fry.

Council, 2 yrs., R. J. S. Pigott, (Ex-Officio); 1 yr., J. G. Kirkpatrick; 1 yr., A. B. Powell; 2 yrs., C. L. Huffman; 2 yrs., R. H. Knapper; 1 yr., R. M. Kondig.

Mr. Rimbach reported on "Instrumentation for Tomorrow" Exhibit. An announcement was made stating that the Exhibit would be postponed until February.

The speaker for this meeting was W. B. Heinz, Consulting Engineer and director of a program of pneumatic instrument development for the Cochrane Corporation. He discussed the "Comparisons of Force-balance and Position-balance Control Mechanism." He stated that proportional controllers "follow up" a change in position or force from the measuring means by a balancing change in another position or force. They can thus be classified as "position balance" and "force-balance" devices. A universal force-balance pneumatic relay was explained and illustrated by slides. Other photographs showed a novel pneumatic instrument for transmitting the position of a rotameter float. The output air pressure can be used by receiving instruments for indicating, recording and controlling flow. The force-balance principle has also been utilized in a new recorder-controller of which photographs were shown. A highly refined instrument, this recorder-controller includes all features which are customarily provided by corresponding equipment and additional advantages which arise from the force-balance principle. One of the universal

A Message from the I.S.A. President *pro tem*

HUBBARD ENGINEERING COMPANY
225 N. Michigan Ave., Chicago 1, Illinois

June 1945

The *pro tem* Officers and Council of the Instrument Society of America, and the Delegates selected by the various Local Sections, have been given two objectives: First, to establish the permanent organization of the Society and to transfer the management to the duly elected Officers at the earliest possible date. Second, to learn the wishes of the members of the Society and translate these into a policy which truly expresses their wishes.

In order to formulate policies which are truly expressive of the desires of the Membership, we will need your help and advice. Your Officers will attempt, during the next several months, to discuss these questions personally with as many of the Sections as possible, but we hope that every Member will express, either personally to visiting *pro tem* officials and to his own Delegates, or by writing to us, just what he hopes the Instrument Society of America will do for him and for the Instrument Fraternity generally.

We invite you, therefore, to help in the formulation of the policies of your Society, and in the establishment of the basic policies and traditions which will help the Instrument Men of our country assume their proper place in the Instrument World of the future.

ALBERT F. SPERRY, *President pro tem*

Do you want SIMPLICITY

IN MAKING

Moisture Tests?

Ease of operation is as much a feature of the Steinlite, One Minute Moisture Tester, as speed and accuracy. It is as easy to use as tuning a radio. No previous experience is needed to make fast, accurate tests.

About all you do is weigh out a sample, pour it into hopper, press a button, compare the meter reading with a conversion chart, and you have the answer. Exact results can be obtained in one or two minutes . . . and that is a tremendous saving compared to 30 minutes or more required by old-fashioned methods.

The STEINLITE One Minute Moisture Tester

The Steinlite operates on the electrical impedance principle . . . and is calibrated against the official method for each product. It is used on a great variety of products.

OUR ENGINEERS WILL CHEERFULLY HELP YOU SOLVE YOUR MOISTURE TESTING PROBLEMS.

SEEDBURO EQUIPMENT COMPANY

644 BROOKS BUILDING
CHICAGO 6, ILLINOIS

ASKANIA *Hydraulic Jet*

Now HAS A PARALLEL IN *The* ASKANIA *Electronic Jet

* PRESENT RESTRICTIONS PREVENT IMMEDIATE USE OR APPLICATION • A FEW TUBES ARE AVAILABLE TO INTERESTED MANUFACTURERS FOR EXPERIMENTAL PURPOSES

ASKANIA REGULATOR CO.
A GENERAL PRECISION EQUIPMENT CORPORATION SUBSIDIARY
1605 S. MICHIGAN AVENUE, CHICAGO 16, ILLINOIS

INSTRUMENT SOCIETIES CALENDAR

City, Society and Secretary			Date	Place	Subject	Speaker
Atlanta, Georgia	Georgia Society for Measurement & Control	Robert E. Geminert, P.O. Box 1714, Atlanta		Blue Flame Room, Atlanta Gas Light Co.		
Baltimore Maryland	Baltimore Industrial Instrumentation Society	J. J. Seglets, 35 S. Potomac St., Baltimore 24		Engineers Club, 6 W. Fayette St., Balto.		
Chicago, Illinois	Chicago Society for Measurement & Control	A. J. Butler, c/o IHC, 2626 W. 31st Blvd., Chicago		M&M Club, 237 Merchandise Mart		
Cleveland, Ohio	Cleveland Instrumentation Society	A. J. McCullough, Minneapolis-Honeywell, 5005 Euclid Ave., Cleveland 3		Cleveland Engineering Society		
Detroit, Mich.	Instrument Society of Detroit	Cliff Sackett, Chrysler Eng'g 12800 Oakland Ave. Det't				
Fort Worth, Texas	Fort Worth Electronics Club	Ralph Ely, 1116 E. Arlington, Fort Worth	June 21(A)	Texas Hotel, Fort Worth	High-frequency Heating	J. L. Caudry, Texas El
Gulf Coast (Texas)	Gulf Coast Instrument Maintenance Men's Ass'n	T. H. Pierson, 3030 Roberts St., Beaumont, Texas				
Hartford, Conn.	Hartford Society for Measurement & Control	Gustave L. Manke, c/o Veeder-Root, Sargent & Garden Sts.		Bond Hotel		
Kansas City, Missouri	KC Industrial Instrumentation Society	Gordon H. Burke, 1527 Broadway, Kansas City, Mo.	June 22	Santa Fe Hills Country Club	(Not a technical meeting but a DANCE)	
Los Angeles, Calif.	California Instrument Society	M. D. Pugh, 541 South Spring St., Los Angeles, Calif.		Melody Lane, Los Angeles		
Newark, N. J.	Society for Measurement & Control (New Jersey)	H. L. Close, 831 Dixie Lane, Plainfield, N. J.		Essex House		
New York, N. Y.	New York Society for Measurement & Control	H. L. Hildenbrand, 206-07 33d Ave., Bayside, L.I., N.Y.	June 26(B)	Columbia U. Men's Faculty Club, 400 W. 117th St.	The Air Position Indicator	V. R. Kimball, Eclipse Pioneer Div., Bendix
N. Indiana	Northern Indiana Soc. for Measurement & Control	K. M. Frame, 25 Ruth St. Hammond, Indiana		Lake Hotel, Gary		
Philadelphia, Pa.	Philadelphia Society for Instrumentation	G. E. Gress, c/o ATC, 34 E. Logan St., Philadelphia	June 20(B)	Engineers Club, 1317 Spruce St.	Notes on control of refinery processes	H. F. Moore, Standard Devel. Co.
			Sept. 19(B)		(To be announced)	T. F. Robertson, Corning Glass Works
Pittsburgh, Pa.	American Society for Measurement & Control	L. M. Susany, c/o Carnegie Institute, 4400 Forbes St.	Sept. 24(B)	Roosevelt Hotel	Electronic instruments for process control	D. M. Nielson, The Foxboro Co.
St. Louis, Mo.	St. Louis Society for Instrumentation	Gus Holubeck, Union Electric Co., Venice, Ill.				
Kingsport, Tenn.	Tennessee Section, I. S. A.	C. F. Palmer, 2924 J. C. Hwy., Kingsport				
Toronto, Ontario	Canadian Society for Measurement & Control	T. C. Agnew, Minneapolis-Honeywell Reg. Co.		Diana Sweets, 188 Bloor St. W., Toronto		
Washington, D. C.	Instrument Society of Washington	W. A. Wildhack, National Bureau of Standards, Wash'n		Interior Dep't Auditorium		
Whiting, Indiana	Whiting Instrument Men's Guild	Lloyd Clouse, 7344 Dante Ave., Chicago 19, Illinois				
Wyandotte, Mich.	Instrument Society of Wayne County	D. J. McCloskey, 116 Oak St., Wyandotte, Mich.	June 25	West Mound Methodist Church	Flowmeters—Panel Discussion	Three discussion leaders

(A) Meeting at 7:30, no dinner (B) Dinner at 6:30, meeting at 8 (C) Dinner at 7, meeting at 8 (D) Meeting at 8, no din

relays was demonstrated as a pressure amplifier, capable of amplifying small input pressure changes by factors which are readily adjustable from unity to well over 1000. Some of the numerous potential applications of this amplifier were described.

Through the courtesy of the George Gorton Company of Racine, Wisconsin, a sound motion picture in color entitled "An Exact Duplicate" was shown which featured some of the lesser known applications of the Gorton Tracer Control Machines.

This was the last meeting until next fall.

—L. M. SUSANY, *Secretary*

TENNESSEE

On Tuesday night, May 8, in the club room of the Recreation Building at Tennessee Eastman Corporation, Kingsport, Tenn., the Tennessee Section of the Instrument Society of America had its first meeting under its new name. (The former name was the Appalachian Society for Measurement and Control.)

The meeting was strictly business and our president, Mr. H. L. Jankey, made a report on the national meeting held in Pittsburgh, April 28 and pointed out the advantages of being a member of the National Society. Certain points were discussed by the members and a unanimous vote was cast in favor of our entering the Instrument Society of America as the Tennessee Section.

Just before we were adjourned we also voted unanimously on having a special meeting and dinner on the following Friday night, May 12, at the Kingsport Inn, at which time we would have Mr. Ralph Clarridge and Mr. Warren Gray of Taylor Instrument Companies address us.

On Friday night, the 12th, Mr. Clarridge spoke to us. The subject of his talk was "The History of Control Development at Taylor Instrument Companies." He began by telling us of the forming and growth of the companies and brought out the approximate dates of each major development. He made sketches and pointed out the principles upon which they function. He was very open minded in his discussion, reminding us that other instrument companies were doing similar work in the development of controls at the same time. Mathematical theory was cut to a minimum. General principles and practical applications were high-lighted.

Members and guests who were present expressed interest and no doubt were benefited.

CHARLIE F. PALMER, *Secretary*

Secretaries and Publicity Chairmen!

Keep your group in the news even during the no-meeting months! Send *Instruments* reports of committee work, items about individual members, etc.—MFB

WASHINGTON

The 1944-45 season's last formal meeting of the Instrument Society of Washington was held on May 15. Mr. George W. Cook, Chief of the Electronics Section, D. W. Taylor Model Basin, spoke on the Carrier Type Strain Indicator developed at the Model Basin, discussing specially-constructed strain gages, a novel bridge circuit incorporating an automatic calibrator, and the application to specimens. His talk was illustrated with slides and models, and brought forth lively discussion and questions, indicating the general interest in the subject.

As a supplementary feature, a short film was shown illustrating the Sperry Attitude Gyro Indicator.

A report on the Pittsburgh organizational meeting of the Instrument Society of America was submitted by the President, Mr. Darnell.

—W. A. WILDHACK, *Corresponding Secretary*

WYANDOTTE

The Instrument Society of Wayne County met May 28th. Our president, Mr. Baker reported on his work and findings as delegate to the meeting of Instrument Society of America. We were glad to learn that we are one of the first fifteen charter member groups.

Mr. C. B. Moore of Moore Products Co. was the guest speaker. His topic was "The Pneumatic Null Balance System applied to Industrial Instruments." There were slides and descriptions of applications to temperature and pressure instruments, flow and liquid level, remote transmission, and valve positioners. Mr. Moore had some new points on automatic control and was able to clear away the haze on proportional response, automatic reset and pre-act.

The talk was very interesting and beneficial. There were numerous questions during and after the meeting, and many expressions of appreciation.

JOHN MACPHERSON, *Vice President*

RAWSON D.C. MULTIMETERS

Type 501A
Accuracy ½ of 1%

Readings from 2 microamps to 1 ampere on 5 ranges, and 20 microvolts to 1000 volts on 9 ranges.

Also

THERMAL MULTIMETERS FOR A.C.

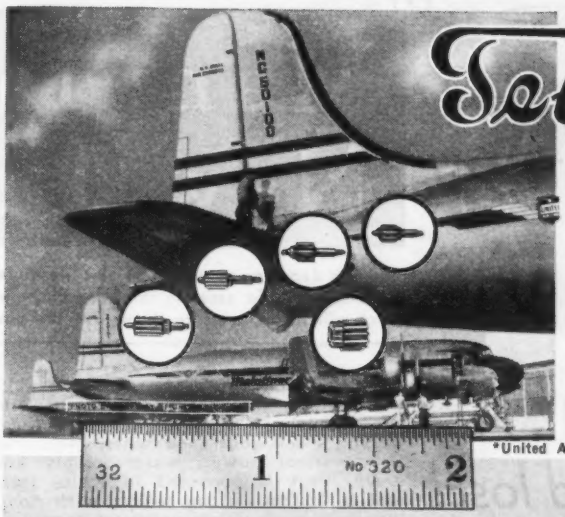
Special Apparatus Built to Order

RAWSON ELECTRICAL INSTRUMENT COMPANY

110 POTTER ST. CAMBRIDGE, MASS.

Representatives

CHICAGO NEW YORK CITY



Tel-air

"MEANS PRECISION *to the nth degree"*

Rule shows how small these tiny pinions are—yet tiny gears like these have a vital part in the success of a giant machine's operation.

*United Air Lines Photo

Another Tel-Air Part
Small Tel-Air gears showing comparative size

THE BIG JOB *of the* TINY GEAR

PRECISION INSTRUMENT MAKERS & USERS:

The Teleoptic Company's exceptional engineering experience and modern facilities will be of immediate help to you in solving many of the problems arising from today's requirements.

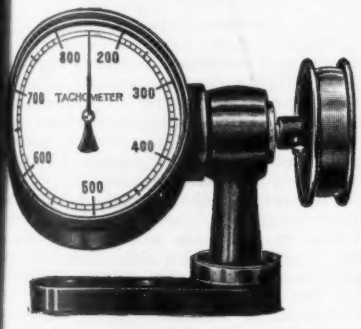
If you have any product using tiny mechanisms which must operate with unfailing precision and accuracy, we can make them to your complete satisfaction. We have an enviable record for deliveries on schedule.

Bomb fuzes, in which pinions shown are used attest the dependability of Tel-air engineering.

*Planes illustrated are the 4-engine type which United has ordered for post-war service.

In the Air it's Tel-air — The TELEOPTIC Company, 1265 MOUND AVENUE • RACINE, WISCONSIN — On the Highway it's Teleoptic

Amthor



STATIONARY TACHOMETERS

CENTRIFUGAL TYPE

Indicating R.P.M., F.P.M., etc.
Belt, Sprocket, or Flexible Shaft drives

Models available for practically every requirement.

Immediate and intelligent attention will be given to your inquiries on all industrial speed measurement problems. Drop us a line today.

Amthor Testing Instrument Co., Inc.
49a Van Sinderen Ave. Brooklyn, N. Y.

FIELD VACUUM THERMOCOUPLES

For Accurate

HIGH FREQUENCY MEASUREMENTS

Full Size

FIELD thermocouples meet the most rigid specifications of prominent instrument makers.

The "Thoro-Weld" process used in FIELD 100% welded thermocouples insures utmost sturdiness.

All couples individually tested.

Stable output over long time assured by special processing.

Available in a wide variety of standard ranges beginning at 1.2 milliamperes—or to your own specifications.

Just released . . . NEW DEVELOPMENT giving 25 millivolts output in a vacuum couple. Available now—in ranges of 100 milliamperes and over.

Write for informative bulletin. Attention Dept. 8

FIELD ELECTRICAL INSTRUMENT CO.
109 EAST 184 ST., NEW YORK 53, N. Y.

Interval Timers

Process Timers

Signal Timers

Time Switches

Relays

Write

AUTOMATIC ELECTRIC MANUFACTURING CO.
MANKATO, MINNESOTA

He guessed . . . *and lost!*

They say that successful race track gamblers *never guess . . .*

There are no "odds" to compensate for a wrong guess when you're counting revolutions, or surface feet or yards of material or tons of output. . . . You need exact information, and a miss is as good as a mile.

Why guess when Corbin Tachometers will do your counting accurately and continuously? Use them in your plant — install them as part of the equipment on your machines — and let their *facts* improve your production and service.

PA-3

Call on us for prompt, complete information on Tachometers. They can be engineered to meet your special requirements.

THE CORBIN SCREW CORPORATION
The American Hardware Corporation, Successor
NEW BRITAIN • CONNECTICUT

CORBIN
TACHOMETERS

Manufacturers' New Literature

In this department we report new literature pertaining to Instrumentation, received from manufacturers. To assist in the War Effort we urge readers to request ONLY those bulle which will be of value to them. Use the coupon on the facing page.

M-151 **Film Processor.** 4-page 8½" × 11" bulletin pictures and describes 16-mm. Model 11 reversal film processor which is self-contained when connected to electrical power, water supply and drain. Unit is operated in white light and is driven by top rollers with floating bottom elevators assuring threading ease and uniform tension. Solution tanks, cabinet, waterjackets, pipes bearings and shafts are all of stainless steel. Unit has a capacity of 15' of reversal film per minute; 5' of negative film per minute, at 8 minutes developing time; and 20' of positive film per minute at two minutes developing time. The Houston Corp., 11801 Olympic Blvd., Los Angeles 25, Calif.

M-152 **Cathode-ray Oscillograph.** 4-page 8½" × 11" bulletin pictures and describes Du Mont Type 208 oscillograph having a vertical and horizontal frequency range from 2 to 100,000 sinusoidal cycles per second and a voltage gain of 2,000 times vertically and 43 times horizontally. Maximum deflection factor; Y-axis amplifier, at zero attenuation is 0.010 r.m.s. volts per inch, X-axis amplifier 0.5 r.m.s. volts per inch. Bulletin includes information on cathode-ray tube, input impedance, input potential, power supply, sweep circuit, horizontal switching, diagram of block circuit arrangement and diagram of input circuit. Allen B. Du Mont Laboratories, Passaic, N. J.

M-153 **Temperature Control for Coolants.** 10-page 8½" × 11" Bulletin MAF-2 describes "Airtemp" liquid cooler for keeping at a constant temperature the cutting oils and coolants which flow over work on machine tools. Airtemp Division of Chrysler Corp., Dayton, Ohio.

M-154 **Voltage Regulators.** 4-page 8½" × 11" Bulletin 116 describes and illustrates new Types "116" and "216" voltage regulators of 1-kva. capacity for 115-volt and 230-volt inputs respectively. Output ranges are 0-135 and 0-270 volts respectively. By changing internal terminal connections, however, user can limit output voltages to input voltages. Superior Electric Co., Bristol, Conn.

M-155 **Dial Indicator Tester.** 4-page 8½" × 11" bulletin pictures and describes the "Clarkator" for checking dial indicators with sine bar accuracy. Instrument uses an inclined plane which measures the tangent of the angle for testing. Can be easily operated requiring only four steps. Instrument checks clearance between bushing and spindle, friction in indicator, calibration on dial, calibration of indicator for accuracy, back lash or gear clearance and indicator travel. Bulletin also includes specifications and operating instructions. Clark Instrument Inc., 10200 Ford Rd., Dearborn, Mich.

M-156 **Flow Meter.** 8-page 8½" × 11" Bulletin 318-B illustrates and describes Builders "Flo-watch," a recording, indicating and totalizing mechanical flow meter for measuring liquids, steam, air or gas. Instrument measures flow through standard differential producers such as Venturi tubes, nozzles and orifices. It also adapted for use with Kennison o nozzles, flumes and weirs. Bulletin cludes cut-away section of measur mechanism, and differential well, and lustrates diagramatically several typ installations. Builders-Providence, I Providence 1, Rhode Island.

M-157 **Pilot Valves for Hydraulic S tems.** 24-page 8½" × 11" Bulletin illustrates and describes Vickers p valves for use as the initial or seque tial control of other valves or eleme in oil hydraulic power systems. Val are available in rotary type either single or double units for manual, chanical and electrical operation. Plu er type available as roller or solen operated. Bulletin also includes instal tion specifications, types of mountin types of control levers, diagrams of ternal oil flow, functional details diagrams of typical installations. Vick Inc., 1400 Oakman Blvd., Detroit 32, Mi

M-158 **"Faxfilm" Comparator Appar tus.** 4-page 8½" × 11" circular pictu and describes "Model C1000" instrum for surface inspection and compari using "Faxfilm" clear plastic f method; one frame standard finish the other frame containing replica surface to be studied. Circular includ descriptions of hand viewer, micropr jection kit, etc. Rex D. McDill, 5109 M field Road, Cleveland 21, Ohio.

M-159 **Vacuum Tubes.** 32-page 8½" 11" "Taylor Tube Catalog and Manua pictures and describes a number of tu now available for distribution. Catal contains information on all tubes man factured by this firm in the pre-war da new tubes developed as result of war d mands, technical information on tran mitters, tube characteristics, rectifi and interchangeability chart. Also i cludes price list and tube index. Th catalog is available without charge local distributors of Taylor Tubes in ea district or it may be obtained direct from the plant on prepayment of 25c cover mailing costs. Taylor Tubes In 2312-18 Wabansia Ave., Chicago 47, Ill.

M-160 **Dynamic Pressure Gage.** 8½ × 11" Data Sheet No. 110 pictures an describes Trimount Dynamic Pressur Gage used for making static and dynam ic pressure measurements for eithe ground or flight test work. Can be use with carrier system or equipment fo acceleration, vibration and strain mea urements. Gage utilizes principle of a impedance bridge, temperature compen sation accomplished by mounting imped ances in body. Sheet includes specifica tions and characteristics of Trimount carrier system. Trimount Instrument Co 37 W. Van Buren, Chicago 5, Ill.

M-161 **"Modern Precision."** 10-page 10½" × 15½" issue (identified as Vol. 5, No. 1) of the L&N house organ has a diversified table of contents under the headings of "Metal Industries," "Process Industries," "Petroleum and Ceramics," "Power Plant," "Research, Teaching and Testing" and "L&N Publications." A few

f the articles are: Improved Tool Hardning Helps the Whole Shop; More Steel rom Open Hearth Furnaces; Output of old Drawn Wire Speeded; Kiln Operaion Helped Three Ways; Nitrate Plant peeds Gas Analysis; Micromax Recordrs for CO_2 and pH; Silica Brick Temeratures; Balance Principle Applied oth to Measurement and Control; tretch Your Manpower. Leeds & Northup Company, 4908 Stenton Avenue, Philadelphia 44, Pa.

M-162 **"Report at Mid Century."** 28-page 6" × 9" brochure commemorating the completion of fifty years in business. The company's growth is traced through the years 1895 to 1945 and many interesting developments in the electrical field interlace with the history of this company such as the introduction of electric lighting into the White House by President Harrison in 1889, the importation of the pioneer equipment related to x-ray in 1904, the development of the "Jagabi" rheostat which was taken on both ahe Arctic and Antarctic expeditions by Admiral Richard E. Byrd and many others. In the last few pages are illustrations of "Megger" insulation testers and ohmmeters; "Frahm" vibration reed tachometers and frequency meters; "Jagabi" sliding-contact and compression carbon rheostats; "Pointolite" lamps; "Jaeger" speed indicators and "Jones" hand tachometers. The James G. Biddle Co., 1211-1213 Arch St., Philadelphia 7, Pa.

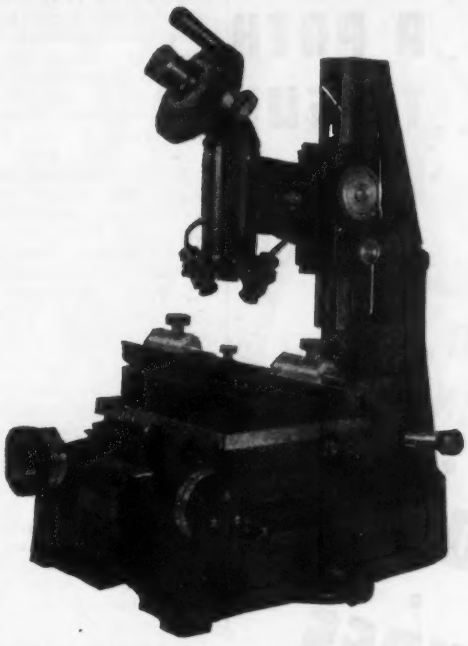
M-163 **"Complete Heat Treat and Metallurgical Equipment Service."** 4-page. 8½" × 11" April 1945 circular of Gordon Service, printed with filing tab, lists the equipment which this company is prepared to supply and service. This list covers furnaces and accessories, pyrometers and furnace instrument accessories, testing equipment, sub-zero equipment, instrument charts, protecting tubes, thermocouples, thermocouple lead wire and insulators and pressure and vacuum gauges. Claud S. Gordon Company, 3000 S. Wallace St., Chicago 16, Ill.

M-164 **Synthetic Optical Crystals.** 16-page 8" × 10" booklet entitled "Revealing New Worlds to Science" gives a brief description of the growth of lithium fluoride, sodium chloride and potassium bromide crystals in the Harshaw Laboratories. The various steps in the process are well illustrated and these illustrations further show the equipment and various types of tools used. The principal uses of the synthetic crystals are described as being for prisms, windows and cells in infrared spectroscopy. A number of these spectrographic curves are shown. The Harshaw Chemical Co., 1945 East 97th St., Cleveland 6, O.

M-165 **Low Capacity Type Rectifiers.** 4-page. 8½" × 11" bulletin describes and illustrates with drawing and diagrams eleven types of "Electrox" rectifier units. Schauer Machine Company, 2060-80 Reading Rd., Cincinnati 2, O.

M-166 **Hydraulic Presses and Accessories for Testing, Control and Research.** 8-page. 8½" × 11" booklet describes equipment for lamination and fabrication, extraction of oils and waxes, compression testing of heavy springs, testing to destruction of building material. In the machine shop for intrusion testing and broaching. For small scale control and experimental work on plastic molding. For testing of molds before turning them over to production. Various sizes for 3 tons to 30 tons shows, all being available with ground heating platens with thermostatic control, electrical thermocouple type temperature indicator, pilot lights and thermometer wells. Laboratory Specialties, Inc., Box 194, Wabash, Indiana.

the **GAERTNER**



TOOLMAKER MICROSCOPE

for length, coordinate and angle measurements

direct to .0001" and 1 minute of arc

Widely used to inspect work in progress and finished work

To measure form tools, milling tools, drill jigs, templets and gauges, machine parts, taps and hobs.

To perform the various thread measurements.

An accurate, reliable and durable instrument incorporating fine machining and carefully adjusted optical parts.

Send for Bulletin 147-14

THE GAERTNER SCIENTIFIC CORP.

1211 Wrightwood Ave., Chicago 14, U.S.A.

TO PREVENT WASTE AND AID THE WAR EFFORT
(1) Request ONLY the literature that will aid you in your war work.
(2) Paste the coupon on a government postal card addressed to *Instruments*, taking care to make all four edges stick.

Instruments, 1117 Wolfendale St., Pittsburgh 12, Pa. *(June 1945)*

Please have the following catalogs, etc., reviewed in this issue sent to me.

Numbers .....

I also desire further information concerning the following new products described in this month's "New Instruments" Department .....

.....

I also desire further information concerning the following products advertised in this issue (Write page number and name of company)

Name .....

Company ..... Position .....

Co.'s Address .....

(OR) Home Address .....

OVER 10,000 ITEMS IN STOCK

•

RADIO PARTS

•

TUBES

•

Electronic Equipment

TO MEET URGENT PRIORITY REQUIREMENTS

Everything in

TUBES · METERS · CONDENSERS
RESISTORS · TRANSFORMERS
TEST INSTRUMENTS · WIRE
AMPLIFIERS · SOUND SYSTEMS, etc.

★

SUPPLIERS TO

Industrial Manufacturers • Research Laboratories • Schools • Colleges
Government Agencies • Railroads
Public Utilities • Broadcast Stations
Hospitals • Shipyards • Police Depts.,

PURCHASING AGENTS!
ENGINEERS!
Send for this
FREE 800 PAGE CATALOG!

Write today on your company letterhead for this massive 800 page Buying Guide containing everything in radio-electronics. Complete listings of all standard nationality known products in one handy, bound volume! Sent free on request by addressing Box UI

SUN RADIO
& ELECTRONICS CO.
212 Fulton Street, New York 7, N. Y.

M-167 **Simplified Means of Selecting Rubber Insulated Engine Mountings.** 2-page 8½" × 11" Bulletin No. B U-23 shows a simplified formula for calculating the proper mounting for any given load, as well as dimension drawings of four typical mountings capable of handling loads of 20 to 600 lbs. Bushings, Inc., 8-155 General Motors Bldg., Detroit 2, Michigan.

M-168 **Precision Resistors.** 2-page 8½" × 11" March 1945 issue of "The Ohmite News" describes "Series 82" and "83," two new additions to the Ohmite Rite-ohm Precision Resistor family, developed to meet the greatly increased demand for precision resistors capable of being mounted by means of a through-bolt and equipped with either radial wire leads or with two lugs at one end. A few common uses for such resistors are for voltmeter multipliers, laboratory equipment, radio and electrical test sets, attenuation pads and un-electronic equipment requiring extremely accurate resistance components. Ohmite Manufacturing Co., 4835-41 Flournoy St., Chicago 44, Ill.

M-169 **"Electronic Pneumatic Mechanical Instrumentation."** 30-page 8½" × 11" issue (identified as Vol. 1, No. 4) of the Brown Instrument house organ features the following articles: (1) Control of a temperature altitude chamber, (2) A tool for automatic control system research, (3) Automatic process control systems—electric and pneumatic, (4) Control systems for smoke houses, (5) Instrumentation of lard manufacturing processes, (6) Instrumentation of Banbury mixers, (7) Control systems for hot blast temperatures, (8) Pressure control, (9) Control systems for desuperheaters, (10) The measurement of flame radiating characteristics, (11) Thermocouples — their selection, application and limitations. The Brown Instrument Company, Wayne and Roberts Aves, Philadelphia 44, Pa.

M-170 **"Seeing It Through."** 56-page 6" × 9" booklet, well-illustrated, describes in an interesting and entertaining manner the major part optical instruments played in World War II. This instructive booklet may be read in twenty minutes. The articles featured are: (1) Optical Foundations, (2) M-Day (3) More — Faster — Better, (4) Crown Jewel of Victory, (5) The Eyes of War (6) 10,000 War Workers, (7) Tributes to Accomplishment. The articles are illustrated by 66 pictures showing the important steps in optical glass manufacture and applications of the finished product to War uses. Bausch & Lomb Optical Company, Rochester, N. Y.

M-171 **Electronic Measuring Instruments Catalog.** 6 sheets 8" × 10½" bring this catalog up to date. Page B, latest price list for service test equipment, production test equipment and precision measurement equipment for laboratory use. Page 1, Service testing, Unimeter. Page 5, Service testing, beat frequency audio oscillator. Page 7, Service testing, oscilloscope. Page 9, Service testing, signal generator, type SG-2A. Page 10, Service testing, signal generator, type SG-3A. General Electric Company, Electronics Department, Schenectady, N. Y.

M-172 **"Aminco Laboratory News."** 8-page 8½" × 11" issue (identified as Vol. 2, No. 3) of this house organ is devoted to the application of scientific instruments to modern laboratory technique, engineering, material testing, and production control. Contains many interesting shorts on the latest developments of science. The equipment featured is: air conditioning units, sub-zero cabinets, metering pump, automatic pipetting machine, electric heaters and controls, temperature controls, hardness testers and constant temperature ovens. American Instrument Company, 8030-8050 Georgia Ave., Silver Spring, Maryland.

M-173 **Calibrated Wear Test.** 16-page 8½" × 11" Abraser Testing Handbook describes the principle of Taber abraser, which provides a standard value for the wearability of materials and surfaces. A few typical examples of materials whose wear factor can be readily determined, such as paints, rubber, synthetic materials, electro-plate, leather, linoleum and textiles are shown. Also shown are accessories are the multiple specimen holder, vacuum pick-up and carrying case. Taber Instrument Corporation, North Tonawanda, N. Y.

ADVERTISERS' INDEX

Aerovox Corporation A16
Air Express Division, Railway Express Agency 431
American Cystoscope Makers, Inc. 405
American Gas Accumulator Co. 440
American Lens Company 403
American Time Products, Inc. A14
Ames Company, B. C. 418
Amthor Testing Instrument Co. 447
Arnold Engineering Company A6
Askania Regulator Company 445
Associated Research, Inc. 422
Automatic Electric Mfg. Co. 447
Aviometer Corporation ..... Inside Back Cover
Bailey Meter Company 411
Bakelite Corporation A29
Barton Instrument Company 424
Belfield Company, H. A18
Biddle Company, James G. 433
Bowser, Inc. A10
Bradley Laboratories, Inc. A12
Breeze Corporations, Inc. 396
Bridgeport Thermostat Co. A19
Burgess Battery Company ... 426, 442
Certified Gauge & Instrument Corp. A32
Chace Company, W. M. A4
Chelsea Clock Company 440
Chicago Metal Hose Corp. 409
Cinaudagraph Corporation A8
Clarostat Manufacturing Co. 441
Cochrane Corporation A7, A30
Cole Steel Equipment Co. 418
Conant Electrical Laboratories .. 435
Concord Radio Corporation 412
Connecticut Tel. & Elec. Div. ... A25
Continental Machines, Inc. A37
Corbin Screw Corporation 448
Dillon & Co., Inc., W. C. 416
Distillation Products, Inc. 439
Dow Corning Corporation 401
Drake Manufacturing Company .. 443
Du Mont Labs., Inc., Allen B. . A2
Elgin National Watch Co. A15
Federal Products Corporation ... 413
Federal Telephone & Radio Corp. A23
Fenwal, Incorporated A36
Field Electrical Instrument Co. . 447
Fischer & Porter Company A21
Foxboro Company, The A9
Gaertner Scientific Corp., The . 449
General Electric Company 438
General Radio Company A1
Great Amer. Industries, Inc. A25
Hammel-Dahl Co. A33
Hays Corporation 413
H-B Instrument Company, Inc. . 417
Heise Bourdon Tube Labs. 407
Hewlett-Packard Company A20
Hickok Elec. Instrument Co. ... 427
Hopp Press, Inc., The 438
Illinois Testing Labs., Inc. 405
Indiana Steel Products Co., The . A22
Jack & Heintz, Inc. 394-395
James Knights Co., The 441
J-B-T Instruments, Inc. 429
Kelnor Manufacturing Company . A32
Kenyon Instrument Company, Inc. A27
Kester Solder Company 407
Leeds & Northrup Company A38
Lenz Electric & Mfg. Co. A35
Lewis Engineering Company A5
Liquidometer Corporation 407
Lustrolite Cleveland Corp. A32
Marion Elect. Instr. Co. A31
MB Manufacturing Company ... A26
Mead Specialties Company 409
Measurements Corporation ..... Back Cover
Meriam Instrument Co. 405
Mobile Refrigeration Division . A10
Moeller Instrument Company ... 404
Moisture Register Company A38
Ohmite Manufacturing Co. 402
Oster Mfg. Company, John 417
Palmer Company, The 434
Paragon Electric Company 406
Permo, Incorporated 406
Philadelphia Thermometer Co. ... 445
Polan Industries 399
Pyrometer Instrument Co. 443
Railway Express Agency 431
Rawson Electrical Instr. Co. 447
Refinery Supply Co., The 412
Rex Rheostat Company 443
Rhodes, Inc., M. H. A34
Roller-Smith Company 421
Rubicon Company 441
Scherr Company, Inc., George . 409
Seeburo Equipment Company ... 445
Shore Instrument & Mfg. Co. ... 443
Simplex Valve & Meter Co. A24
Simpson Optical Mfg. Co. 417
Sola Electric Company 419
Speedway Manufacturing Co. 440
Standard Transformer Corp. 428
Statham Laboratories 410
Sticht Co., Inc., Herman H. 442
Streeter-Amet Company 413
Struthers-Dunn, Inc. A13
Sun Radio & Electronics Co. 450
Superior Electric Company A28
Tagliabue Division, Portable Products Corp. Inside Front Cover
Teleoptic Co., The 447
Televiso Products, Inc. 437
Trimount Instrument Co. ... 414, 415
Trinity Equip. & Supply Co. 441
Triplett Electrical Inst. Co. 429
United Transformer Company ... 416
Universal X-Ray Products, Inc. . A36
Wallace & Tiernan Products, Inc. A17
Waltham Screw Company 406
Ward Leonard Electric Co. 406
Warren Telechron Company A11
Waugh Laboratories 425
Weksler Thermometer Corp. 432
Weston Elec. Instrument Corp. .. A3
Wrigley Jr. Company, Wm. 436